Notice No.9

Rules and Regulations for the Classification of Ships, July 2016

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately. Please note that paragraphs, Tables and Figures are not shown in their entirety.

Please note that corrigenda amends to paragraphs, Tables and Figures are not shown in their entirety.

Issue date: June 2017

Amendments to	Effective date	Mandatory Instrument
Part 5, Chapter 1, Section 1	1 July 2017	NA
Part 5, Chapter 2, Sections 1, 2, 12 & 13	1 July 2017	NA
Part 5, Chapter 2, Section 1	Corrigenda	NA
Part 5, Chapter 9, Sections 2 & 3	1 July 2017	NA
Part 5, Chapter 9, Sections, 5 & 6	1 July 2017	X
Part 5, Chapter 14, Sections 2 & 4	1 July 2017	X
Part 5, Chapter 16, Section 2	1 July 2017	NA
Part 5, Chapter 16, Section 3	1 July 2017	X
Part 5, Chapter 19, Sections 1, 2, 4, 5, 6 & 7	1 July 2017	X
Part 5, Chapter 19, Sections 4 & 5	Corrigenda	NA
Part 5, Chapter 20, Sections 1 & 2	1 July 2017	X
Part 5, Chapter 24, Section 1	1 July 2017	X
Part 6, Chapter 1, Sections 1, 2 & 7	1 July 2017	X
Part 6, Chapter 2, Sections 1, 5, 6, 15, 16 & 21	1 July 2017	X
Part 6, Chapter 2, Sections 1 & 14	1 July 2017	NA
Part 7, Chapter 5, Section 5	1 July 2017	X
Part 7, Chapter 12, Sections 2 & 4	1 July 2017	NA
Part 8, Chapter 1, Sections 1, 2 & 3	1 July 2017	X
Part 8, Chapter 2, Sections 1, 2, 4, 6, 10 & 12	1 July 2017	X

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Part 5, Chapter 1
General Requirements for the Design and Construction of Machinery

■ *Section 1*
General

1.3 Alternative approach for product assurance

1.3.1 LR will be prepared to give consideration to the adoption of an approach for product assurance, utilising regular and systematic audits of ~~the approved manufacturing and quality control processes and procedures~~ an organisation's arrangements for assuring product quality as an alternative to the direct survey of individual items.

1.3.2 Alternative approaches for product assurance are to be approved by LR. In order to obtain approval, the requirements of *Pt 5, Ch 1, 6 Quality Assurance Scheme for Machinery* or the *Rules for the Manufacture, Testing and Certification of Materials, July 2016, incorporating Notice No. 1 & 2, Ch 1, 2.4 Materials Quality Scheme* are to be complied with. Proposals for equivalent approaches are to be submitted for consideration.

Part 5, Chapter 2
Reciprocating Internal Combustion Engines

■ *Section 1*
General requirements

1.1 Approval process

1.1.1 All engines intended for installation on an LR Class ship are to be Type Approved by LR~~; LR Type Approval is explained in *Pt 1, Ch 2, 5.1 LR Type Approval — Marine Applications*~~ (*see* Lloyd's Register Type Approval System Procedure TA14 for details of the LR Type Approval process).~~ LR Type Approval of an engine type will be granted following:~~
~~(a) satisfactory design appraisal (*see Pt 5, Ch 2, 1.2 Submission requirements* for submission requirements).~~
~~(b) approval of type testing programme and satisfactory type testing (*see Pt 5, Ch 2, 14.1 Engines*).~~
~~(c) acceptance of the place of manufacture (meet LR requirements for conformity of production.~~

1.1.5 An LR Engine Certificate is issued upon satisfactory completion of engine assembly, with associated component testing (*see Pt 5, Ch 2, 2 Materials and Components*) and factory acceptance testing (*see* Pt *5, Ch 2, 11 Factory Acceptance Test and Shipboard Trials of Engines*) or, issued in accordance with the alternative approach for product assurance approved by LR, *see* ~~*Pt 5, Ch 2, 1.1 Approval process*~~ *Pt 5, Ch 1, 1.3 Alternative approach for product assurance*.

~~1.1.7 The engine manufacturer is to apply an approach for product assurance that is suitable for, and includes, the engine types to be certified, *see Pt 5, Ch 1, 1.3 Alternative approach for product assurance* and *Pt 1, Ch 2, 5.3 Quality Control System*. Materials and components are to be manufactured in accordance with this approach and the *Rules for the Manufacture, Testing and Certification of Materials, July 2016*, herein after as applicable.~~

1.2 Submission requirements

Table 2.1.1 Plans and particulars to be submitted

Document	For information	For appraisal
	(x indicates reason for submission)	
Construction of accumulators ~~(common rail)~~ for electronically controlled engine		X
Construction of common accumulators ~~(common rail)~~ for electronically controlled engine		X

■ *Section 2*
Materials and Components

2.2 ~~Test and inspections~~ Testing and inspection

2.2.1 Except where *Pt 5, Ch 2, 2.2 Test and inspections* ~~*2.2.1*~~ *2.2.3* applies, materials and components for engines are to be manufactured and tested in accordance with the relevant requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2016, incorporating Notice No. 1 & 2* and *Table 2.2.1 Summary of* *testing and associated* *documentation* ~~*and testing*~~ *for engine components*.

2.2.2 All testing and inspection in *Table 2.2.1 Summary of testing and associated documentation for engine components* is to be documented by manufacturer's certificate, *see Pt 5, Ch 2, 2.2 Test and inspections 2.2.8,* except where LR engagement is explicitly required.

~~2.2.2~~ 2.2.3 Where an alternative approach for product assurance has been approved by LR (*see Pt 5, Ch 1, 1.3 Alternative approach for product assurance*)~~;~~:

(a) Testing and inspection identified as requiring LR engagement in *Table 2.2.1 Summary of testing and associated documentation for engine components* may be carried out and documented by the manufacturer in accordance with the approved alternative approach for product assurance.

~~(a)~~ (b) Any agreed variation to the requirements given in *Table 2.2.1 Summary of* *testing and associated* *documentation* ~~*and testing*~~ *for engine components* is to be included within the alternative approach for product assurance ~~documentation~~ scheme certification schedule.

~~(b) The types of certification as given by (a) and (b) in~~ ~~*Table 2.2.1 Summary of documentation and testing for engine components*~~ ~~may be accepted; otherwise, testing and inspection is to be documented by an LR Certificate. Where (a) or (b) is not specified in~~ ~~*Table 2.2.1 Summary of documentation and testing for engine components*~~~~, the certification requirements as given by the other relevant parts of the Rules apply,~~ ~~*see*~~ ~~Notes to the Table.~~

2.2.4 All material for components listed in *Table 2.2.1 Summary of testing and associated documentation for engine components* is to be from an LR approved manufacturer, and manufactured within the scope of approval of that manufacturer, except where explicitly stated otherwise in other Parts and Chapters of the Rules.

Paragraphs 2.2.3 to 2.2.6 have been renumbered 2.2.5 to 2.2.8.

Table 2.2.1 Summary of testing and associated documentation ~~and testing~~ for engine components

Part	Material properties *see* Note 2	Non-destructive examination	Hydraulic testing *see* ~~Pt 5, Ch 2, 2.3 Hydraulic tests~~ Note 4	Dimensional inspection *see* Note 3	Visual inspection *see* Note 5	Applicable to engines	~~LR Component Certification~~ ~~*see* Note 4~~
Welded bedplate	C + LR(M) ~~(b)~~	UT + CD ~~(b)~~	-	-	LR(V) fit-up + post-welding	All	~~X~~
Bearing transverse girders (cast steel)	C + LR(M) ~~(b)~~	UT + LR(CD) ~~(b)~~	-	-	LR(V)	All	~~X~~
Welded frame box *see* Note ~~5~~6	C + LR(M) ~~(b)~~	UT + CD ~~(b)~~	-	-	LR(V) fit-up + post-welding	All	~~X~~
Cylinder block (cast iron)	LR(M) ~~(b)~~	-	LR(P) ~~(b)~~ *see* Note ~~6~~7	-	-	Crosshead	~~-~~
Welded cylinder frames *see* Note ~~5~~6	C + LR(M) ~~(b)~~	UT + CD ~~(b)~~	-	-	LR(V) fit-up + post-welding	Crosshead	~~X~~
Engine block (cast iron)	LR(M) ~~(b)~~	-	LR(P) ~~(b)~~ *see* Note ~~6~~7	-	-	>400kW/cylinder	~~-~~
Cylinder liner	C + LR(M) ~~(b)~~	-	LR(P) ~~(b)~~ *see* Note ~~6~~7	-	-	B>300mm	~~-~~
Cylinder head (cast iron) ~~*see* Note 7~~	LR(M) ~~(b)~~	~~UT + CD (b)~~	LR(P) ~~(b)~~	-	-	B>300mm ~~*see Note 8*~~	~~-~~
Cylinder head (cast steel)	C + LR(M) ~~(b)~~	UT + LR(CD) ~~(b)~~	LR(P) ~~(b)~~	-	LR(V)	B>300mm ~~*see* Note 8~~	~~X~~
Cylinder head (forged)	C + LR(M) ~~(b)~~	UT + LR(CD) ~~(b)~~	LR(P) ~~(b)~~	-	LR(V)	B>300mm ~~*see* Note 8~~	~~X~~
Piston crown (cast	C + LR(M) ~~(b)~~	UT ~~-~~+ LR(CD)	-	-	LR(V)	B>400mm ~~*see*~~	~~X~~

steel) *see* Note 9		~~(b)~~				~~Note 8~~	
Piston crown (forged)	C + LR(M) ~~(b)~~	UT ~~-~~+ LR(CD) ~~(b)~~	-	-	LR(V)	B>400mm ~~*see* Note 8~~	~~X~~
Crankshaft (one piece)	LR(C + M) ~~(a)~~	UT ~~-~~+ LR(CD) ~~(b)~~	-	D ~~(b)~~	LR(V) (Random, of fillets and oil bores)	All	~~X~~
Semi-built crankshaft (Crankthrow, forged main journal and journals with flange)	LR(C + M) ~~(a)~~	UT ~~-~~+ LR(CD)~~(b)~~	-	D ~~(b)~~	LR(V) (Random, of fillets and shrink fittings)	All	~~X~~
Exhaust gas valve cage	LR(M) ~~(b)~~	-	LR(P) ~~(b)~~	-	-	Crosshead	~~-~~
Piston rod	LR(C + M) ~~(a)~~	UT + CD ~~(b) (CD again after final machining (grinding))~~	-	-	LR(V) (Random)	B>400mm	~~X~~
Crosshead pin	LR(C + M) ~~(a)~~	UT + CD ~~(b) (CD again after final machining (grinding and polishing))~~	-	-	LR(V) (Random)	Crosshead	~~X~~
Connecting rod with cap	LR(C + M) ~~(a)~~	UT + LR(CD) ~~(b)~~	-	D ~~(b)~~	LR(V) (Random, of all surfaces in particular those shot peened)	All	~~X~~
Crankshaft coupling bolts	LR(C + M) ~~(a)~~	UT + CD ~~(b)~~	-	D ~~(b)~~	LR(V) (Random, of interference fit)	All	~~X~~
Bolts and studs for cylinder heads, crossheads, main bearings and connecting rods *see* Note 10	C + LR(M) ~~(b)~~	UT + CD ~~(b)~~	-	TR [thread making]	-	B>300mm	~~-~~
Tie rod *see* Note 11	C + LR(M) ~~(b)~~	UT + CD ~~(b)~~	-	TR [thread making]	LR(V) (Random)	Crosshead	~~X~~
High pressure fuel injection system – valve and pump body (pressure side) *see* Notes 12, 13, 14 and 15	LR(C + M)	-	LR(Lesser of ~~1,5*p*~~*P* or *p*+30~~0~~ ~~bar~~ MPa)	-	-	All	~~-~~
High pressure fuel injection pipes including common rail *see* Notes 12, 14 and 15	LR(C + M)	-	LR(Lesser of ~~1,5*p*~~*P* or *p*+30~~0~~ ~~bar~~ MPa)	-	-	All	~~-~~
High pressure common servo oil system *see* Notes 14 and 15	LR(C + M)	-	LR(Lesser of ~~1,5*p*~~*P* or *p*+30~~0~~ ~~bar~~ MPa)	-	-	All	~~-~~
Coolers, both sides *see* Notes 14 and 16	LR(C + M)	-	LR(P)	-	-	B>300mm	~~-~~
Accumulator of common rail fuel or servo oil system *see* Note	LR(C + M)	-	LR(Lesser of *P* or *p*+30 MPa)	-	-	Accumulators with a capacity >0,5l	~~-~~

14							
Piping, pumps, actuators, etc., for hydraulic drive of valves, if applicable *see* Note 14	LR(C + M)	-	LR(P)	-	-	>800kW/cylinder	~~-~~
Engine-driven pumps (oil, water, fuel, bilge) *see* Note 14	LR(C + M)	-	LR(P)	-	-	>800kW/cylinder	~~-~~
Bearings ~~for~~ (main, crosshead, and crankpin) *see* Note 17	TR [C]	TR [UT]	-	D ~~(b)~~	~~-~~ LR(V)	>800kW/cylinder	~~-~~
~~Turbocharger, shaft and rotor *see* Note 18~~	~~C + M~~	~~UT + CD~~	~~-~~	~~D~~	~~-~~	~~All~~	~~X*see* Note 19~~
~~Turbocharger casing *see* Note 18~~	~~C + M (b)~~	~~-~~	~~Greater of 4,0 bar or 1,5*p* (b)~~	~~-~~	~~-~~	~~All~~	~~X *see* Note 19~~
~~Air compressor including cylinders, liners, covers, intercoolers and after coolers *see* Notes 16 and 20~~	~~C + M (a)~~	~~-~~	~~Air side: P Water side: Greater of 4,0 bar or 1,5*p*(a)~~	~~-~~	~~-~~	~~-~~	~~X~~

SYMBOLS:

B = Bore dimension, refers to engine cylinder bores

C = Chemical composition analysis

M = Mechanical property analysis

~~(a)/(b) = *see* Note 1~~
UT = Ultrasonic testing (*see* Note 1)

CD = Crack detection by MPI or DPT (*see* Note ~~21~~8)

D = Dimensional inspection, including surface condition

p = Maximum working pressure of item concerned

P = Pressure test at 1,5p

V = Visual examination of accessible surfaces ~~(conducted by Surveyor)~~

- = No explicit requirement for documentation or testing

LR ( ) = Test/inspection to be certified by LR except where *Pt 5, Ch 2, 2.2 testing and inspections 2.2.3* applies.

TR[ ] = Test report required for process in brackets (*see ~~Pt 5, Ch 2, 2.2 Test and inspections 2.2.5~~ Pt 5, Ch 2, 2.2 Testing and inspections 2.2.7*)
~~X = LR Component Certificate required once the finished component is in the state required for fitting into an engine~~

~~Note 1. Alternative test certification, *see Pt 5, Ch 2, 2.2 Test and inspections 2.2.2:*~~

- ~~a. stands for a product certificate issued under an alternative system for product assurance approved by LR (equivalent to an LR Certificate), e.g. a QAM Product Certificate, *see Pt 5, Ch 1, 6.3 QAM Scheme Arrangements 6.3.9*, or a Manufacturer's Certificate issued under QAM (*see Pt 5, Ch 1, 6.4 Acceptance of purchased materials, components and equipment 6.4.2*) or MQS (*see Rules for the Manufacture, Testing and Certification of Materials, July 2016 Ch 1, 3.1 General 3.1.3(d)*).~~
- ~~b. stands for a Manufacturer's certificate (*see Pt 5, Ch 2, 2.2 Test and inspections 2.2.6*)~~

Note 1. Ultrasonic testing is not required for components manufactured from cast iron.

Note 2. Material properties include chemical composition and mechanical properties, as identified in the table above~~,~~. ~~and also~~ Where mechanical testing is required this is to include testing of surface treatment, such as surface hardening (hardness, depth and extent), peening and rolling (extent and applied force) as applicable. Mechanical tests are to be conducted after the final heat treatment has been applied.

Note 3. Dimensional inspection is to include assessment of surface condition.

~~Note 4. An LR Component Certificate will be issued for finished components once they are in the state required in order to assemble them into an In cases where an alternative approach for product assurance is in operation, satisfactory review of all manufacturer certified testing (batch or individual) is required before an LR Component Certificate can be issued.~~

Note 4. Hydraulic testing is applied on the water/oil side of the component. The full lengths of cooling spaces are to be tested, where applicable. Where design or testing features may require modification of these test requirements, special consideration may be given.

Note 5. Certificates issued for visual inspection, either following satisfactory survey or under an approved LR Quality Scheme, are to be considered as component certificates.

Note ~~5~~6. Where welding is carried out, welding and welder qualifications are to be carried out in accordance with the *Rules for the*

Manufacture, Testing and Certification of Materials, July 2016, incorporating Notice No. 1 & 2, Ch 12 Welding Qualifications.

Note ~~6~~7. Hydraulic testing is also required for those parts filled with cooling water and having the function of containing the water which is in contact with the cylinder or cylinder liner.

~~Note 7. For the purposes of these Rules, the term 'cylinder head' also refers to 'cylinder cover'.~~

~~Note 8. Ultrasonic examination is required for all cylinder heads and piston crowns. This may be waived for components for engines below the size specified in the column headed 'Applicable to Engines' where alternative means are provided to confirm that the component is free from internal defects. Components manufactured from spheroidal or nodular graphite iron castings may not be suitable for ultrasonic NDE, depending upon the grain size and geometry. An alternative NDE procedure is to be agreed with LR,~~ ~~*see Rules for the Manufacture, Testing and Certification of Materials, July 2016, incorporating Notice No. 1 & 2, Ch 7, 1.8 Visual and non-destructive examination 1.8.4*~~~~.~~

Note ~~21~~8. Magnetic particle testing is to be carried out on ferro-magnetic materials, penetrant testing is only to be carried out on non-ferritic materials. Visual examination alone is not considered sufficient. Magnetic particle and dye penetrant testing are to be carried out when the forgings are in the finished machined condition.

Note 9. Where the piston rod seals the piston crown cooling space, it is to be tested after assembly.

Note 10. *See also Rules for the Manufacture, Testing and Certification of Materials, July 2016, incorporating Notice No. 1 & 2, Ch 5, 3.5 Non-destructive examination 3.5.1* for detailed non-destructive examination requirements for other bolts and studs.

Note 11. Magnetic particle testing of tie rods may be confined to the threaded portions and the adjacent material over a length equal to that of the thread.

Note 12. Where components are subjected to an autofrettage process accepted by LR (*see Pt 5, Ch 2, ~~2.5~~ 2.4 Autofrettage*), the component pressure test may be omitted. The assembled system containing such components is to be shown, where practicable, to be pressure-tight as required for hydraulic systems.

Note 13. Pumps used in jerk or timed pump systems only need to have the assembled high pressure containing components hydraulically tested.

Note 14. *See also Pt 5, Ch 2, ~~Section~~ 8 Piping*. Material certification requirements for pumps and piping components are dependent on the operating pressure and temperature. Requirements given in this Table apply except where alternative requirements are explicitly given in *Pt 5, Ch 12 Piping Design Requirements* and *Pt 5, Ch 14 Machinery Piping Systems*.

Note 15. Where an alternative approach for product assurance approved by LR is in operation, components for engines with a bore of ~~less than~~ 300mm or less may be supplied with test reports (as described in ~~*Pt 5, Ch 2, 2.2 Test and inspections 2.2.5*~~ *Pt 5, Ch 2, 2.2 Testing and inspections 2.2.7*) instead of test certificates for pressure testing and materials tests, *see* ~~*Pt 5, Ch 2, 2.2 Test and inspections 2.2.2*~~ *Pt 5, Ch 2, 2.2 Testing and inspections 2.2.3*.

Note 16. Material and component certification for accumulators or coolers which are classed as pressure vessels are dependent on the operating pressure and temperature, *see Pt 5, Ch 11, 1.5 Classification of fusion welded pressure vessels* and *Pt 5, Ch 11, 1.7 Materials*. Charge air coolers are only to be tested on the water side.

Note 17. Ultrasonic testing is required to prove full adhesion between basic material and bearing metal.

~~Note 18.Category A turbocharger test results are only required if specifically requested. Category B turbocharger testing may be documented by manufacturer's certificate where an approach for product assurance approved by LR is operated, Category C turbocharger materials tests and pressure tests are to be conducted under survey and LR certificates issued.~~ ~~*See Pt 5, Ch 2, 12.1 General 12.1.2*~~~~.~~

~~Note 19. An LR Component Certificate is only required for Category C turbochargers,~~ ~~*see Pt 5, Ch 2, 12.1 General*~~~~.~~

~~Note 20. Manufacturer's certification for materials and pressure testing will be accepted for air compressors with a calculated crankpin diameter of less than 50mm.~~

Note ~~21~~ 18. Magnetic particle testing is to be carried out on ferro-magnetic materials, penetrant testing is only to be carried out on non-ferritic materials. Visual examination alone is not considered sufficient.

~~2.3 Hydraulic tests~~

~~2.3.1 Hydraulic testing is to be carried out on engine components as identified in~~ ~~*Table 2.2.1 Summary of documentation and testing for engine components*~~~~. Hydraulic testing is to be carried out on components for all engine sizes; this may be waived for components for engines below the size specified in the column headed 'Applicable to Engines' where alternative means are provided to confirm that the component integrity is satisfactory.~~

~~2.3.2 Hydraulic testing is applied on the water/oil side of the component. The full lengths of cooling spaces are to be tested, where applicable. Where design or testing features may require modification of these test requirements, special consideration may be given.~~

Sub-Sections 2.4 and 2.5 have been renumbered 2.3 and 2.4.

■ *Section 12*
Turbochargers

12.1 General

12.1.1 Turbochargers are to be approved, either separately or as a part of an engine. ~~The requirements are written for exhaust gas driven turbochargers, but apply in principle also for engine driven chargers.~~

12.2 Works testing and inspection

12.2.1 LR Surveyors are to be provided with free access to the manufacturer’s works to inspect at random the quality control measures and to witness the tests required by *Pt 5, Ch 2, 12.2 Works testing and inspection 12.2.2* ~~to~~ ~~*Pt 5, Ch 2, 12.2 Works testing and inspection 12.2.4*~~ as deemed necessary, and to have free access to all control records and subcontractor’s certificates.

12.2.2 Each individual unit is to be tested in accordance with *Pt 5, Ch 2, 12.2 Works testing and inspection* ~~*12.2.2*~~ *12.2.3 to Pt 5, Ch 2, 12.2 Works testing and inspection* ~~*12.2.4*~~ *12.2.8*. For category C turbochargers these tests are to be conducted under survey unless an alternative approach for product assurance has been approved by LR. For category B turbochargers the testing is to be documented by manufacturer’s certificate. For category A turbochargers, test results, documented by manufacturer’s certificate, are only required if specifically requested by LR.

12.2.4 Material tests (chemical composition and mechanical properties) and dimensional inspection, of the rotating parts and casing are to confirm compliance with the approved design and material specifications (*see Pt 5, Ch 2, 1.2 Submission requirements 1.2.5*). Testing ~~and certification~~ and inspection of turbocharger casings and rotor shafts are to comply with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2016, incorporating Notice No. 1 & 2,* as applicable.

~~12.2.6~~ 12.2.5 ~~Pressure tests are to be carried out in accordance with *Table 2.2.1 Summary of documentation and testing for engine components*. Special consideration will be given where design or testing features may require modification of the test requirements.~~ Cooling spaces are to be hydraulically tested to 0,4 MPa gauge or 1,5 times maximum working pressure, whichever is higher.

12.2.6 Rotating parts are to be subjected to ultrasonic testing and surface crack detection (magnetic particle testing is to be carried out on ferro-magnetic materials, penetrant testing is only to be carried out on non-ferritic materials). Ultrasonic testing is not required for components manufactured from cast iron.

~~12.2.5~~ 12.2.7 All rotors are to be dynamically balanced on final assembly.

~~12.2.7~~ 12.2.8 All compressor wheels are to be overspeed tested for three minutes at either 20 per cent above the alarm level speed at room temperature, or 10 per cent above alarm level speed at 45°C inlet temperature when tested in the actual housing with the corresponding pressure ratio. The overspeed test may be waived for forged wheels that are individually controlled by an approved non-destructive method, this test will not be waived for wheels of the unit to be type tested.

12.3 Certification

~~12.3.1 The manufacturer is to adhere to a quality system designed to ensure that the designer’s specifications are met, and that manufacturing is in accordance with the approved drawings.~~

~~12.3.2~~ 12.3.1 Turbochargers are to be delivered with:
(a) Category B turbochargers: ~~a~~A manufacturer’s certificate, which states the applicable type approval, including production assessment.
(b) Category C turbochargers~~,~~: ~~a~~An LR certificate or LR Quality Scheme Product Certificate as applicable, which states the applicable ~~t~~Type ~~a~~Approval ~~and, if applicable the LR Quality Scheme when applicable~~ and LR Quality Scheme reference, if applicable.

~~12.3.3~~ 12.3.2 Where the manufacturer operates ~~a quality control system agreed with~~ an alternative approach for product assurance approved by LR the periodic audits will include specific focus on:
(a) Chemical composition of material for the rotating parts.
(b) Mechanical properties of the material of a representative specimen for the rotating parts and the casing.
(c) UT and crack detection of rotating parts.
(d) Dimensional inspection of rotating parts.
(e) Rotor dynamic balancing.
(f) Hydraulic testing of cooling spaces ~~in accordance with *Table 2.2.1 Summary of documentation and testing for engine components.*~~ as per *Pt 5, Ch 2, 12.2 Works testing and inspection 12.2.5.*
(g) Overspeed test of all compressor disks as per *Pt 5, Ch 2, 12.2 Works testing and inspection* ~~*12.2.7*~~ *12.2.8*.

~~12.3.4~~ 12.3.3 The above certification and test requirements also apply to replacement rotating parts and casing.

■ *Section 13*
Air compressors

13.5 Testing

~~13.5.1 Air compressors components are to be tested as indicated in *Table 2.2.1 Summary of documentation and testing for engine components.*~~

13.5.1 Cast iron crankshafts for air compressors are to be manufactured and tested in accordance with the *Rules for the Manufacture, Testing and Certification of Materials, July 2016, incorporating Notice No. 1 & 2, Ch 7, 5 Iron castings for crankshafts.* Crankshafts for air compressors manufactured from other materials are to be tested in accordance with the applicable requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2016, incorporating Notice No.1 & 2.* Ultrasonic testing is not required for components manufactured from cast iron.

13.5.2 Cylinders, covers and liners of air compressors are to be subjected to hydraulic pressure tests at 1,5 times the final pressure of the stage concerned.

13.5.3 The compressed air chambers of the intercoolers and aftercoolers of air compressors are to be subjected to hydraulic pressure tests at 1,5 times the final pressure of the stage concerned.

13.5.4 Manufacturer’s certification for materials and pressure testing will be accepted for air compressors with a calculated crankpin diameter of less than 50 mm.

13.5.5 After construction, all compressors are to be subjected to a running test to the satisfaction of the attending Surveyor.

Part 5, Chapter 9
Podded Propulsion Units

■ *Section 2*
General requirements

2.2 Plans and information to be submitted

(*Part only shown*)
2.2.1 In addition to the plans required by ~~Chapters~~ *Pt 5, Ch 5 Gearing, Pt 5, Ch 6 Main Propulsion Shafting, Pt 5, Ch 7 Propellers, Pt 5, Ch 8 Shaft Vibration and Alignment, Pt 5, Ch 14 Machinery Piping Systems* and *Pt 5, Ch 19 Steering Arrangements*, and *Pt 6, Ch 1 Control Engineering Systems* and *Pt 6, Ch 2 Electrical Engineering*, the following plans and information are required to be submitted for appraisal:
(g) The declared steering angle limits are to be stated by manufacturer for each podded propulsion unit;
~~(g)~~(h) Details of intended manoeuvring capability of the ship in each operating condition. (To be declared by the shipyard, *see also Pt 5, Ch 9, ~~3.1 General 3.1.1~~ 5.6 Steering system 5.6.2*)

Ordered listed items (h) to (j) have been renumbered (i) to (k).

~~■ *Section 3*~~
~~Functional capability~~

Section 3 has been deleted in its entirety, contents have been moved to existing sub-Section 6.6 as shown below.

Existing Sections 4 and 5 have been renumbered 3 and 4.

■ *Section ~~6~~ 5*

Machinery design and construction requirements

Existing sub-Sections 6.1 to 6.5 have been renumbered 5.1 to 5.5.

~~6.6~~ 5.6 Steering system

~~6.6.1~~ 6.5.1 The requirements of *Pt 5, Ch 19 Steering ~~Arrangements~~ Systems*~~,~~ ~~*Sections Pt 5, Ch 19, 1 General, Pt 5, Ch 19, 2 Performance, Pt 5, Ch 19, 3 Construction and design, Pt 5, Ch 19, 6 Emergency power, Pt 5, Ch 19, 7 Testing and trials* and *Pt 5, Ch 19, 8 Additional requirements*~~ are to be complied with where applicable. ~~*See also Pt 5, Ch 9, 3.1 General*. The requirements of *Pt 5, Ch 19, 2.1 General 2.1.2* and *Pt 5, Ch 19, 2.1 General 2.1.2* are addressed by *Pt 5, Ch 9, 3.1 General 3.1.2* and the requirements of *Pt 5, Ch 19, 2.1 General 2.1.3* and *Pt 5, Ch 19, 2.1 General 2.1.3* are addressed by *Pt 5, Ch 19, 3.1 General 3.1.4*.~~

~~3.1.1~~ 5.6.2 The arrangement of podded propulsion units is to be such that the ship can be satisfactorily manoeuvred to a declared performance capability. The operating conditions covered are to include the following:

(a) Maximum continuous shaft power/speed to the propeller in the ahead condition at the declared steering angles and sea conditions.
(b) Manoeuvring speeds of the propeller shaft in the ahead and astern direction at the declared steering angles and sea conditions.
(c) The stopping manoeuvre described in *Pt 5, Ch 1, 5.2 Sea trials 5.2.2*.
(d) All astern running conditions for the ship.
(e) Manoeuvring in ice where ice class is required.

5.6.3 Where more than one podded propulsion unit is fitted, *Pt 5, Ch 19, 2.1 Performance 2.1.2* is considered to be met when:

(a) Each podded propulsion unit fulfils the requirements for main steering gear (*see Pt 5, Ch 9, 5.6 Steering system 5.6.4*); and
(b) Each podded propulsion unit is provided with the ability to position and lock the podded propulsion unit in a neutral position after a single failure of its power unit(s) and actuator(s). These arrangements are to be of sufficient strength to hold the podded propulsion unit in position at the ship's manoeuvring speed to be taken as not less than 7 knots, *see also Pt 5, Ch 9, 5.3 Propulsion shafting 5.3.11*. Operating instructions displayed at the locking mechanism's operating position are to include a direction to inform the bridge of any limitation in ship's speed required as a result of the securing mechanism being activated.

~~3.1.2~~ 5.6.4 The main steering ~~arrangements~~ gear ~~are~~ is to be ~~operated by power and capable of changing the direction of the ship's podded propulsion units from one side to the other at declared steering angle limits at an average rotational speed of not less than 0,4 rev/min with the ship initially operating at its maximum ahead service speed.~~:

(a) Of adequate strength and capable of changing direction of the podded propulsion unit from one side to the other in accordance with the declared steering angle limits at an average rotational speed of not less than 2,3 deg/s with the ship running ahead at maximum ahead service speed which shall be demonstrated in accordance with *Pt 5, Ch 9, 9 Testing and trials*; and
(b) Operated by power; and
(c) So designed that they will not be damaged at maximum astern speed.

~~3.1.4~~ 5.6.5 The auxiliary steering ~~arrangements~~ gear ~~are~~ is to be:

(a) Capable of being brought speedily into action in an emergency; and
~~(a)~~(b) Of adequate strength and ~~C~~capable of changing the direction of the ship's podded propulsion unit~~s~~ from one side to the other ~~at~~in accordance with the declared steering angle limits at an average rotational speed of not less than ~~0,083 rev/min~~ 0,5 deg/s, with the ship running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater~~.~~; and
~~(b)~~(c) Operated by power for ships having propulsion power of more than 2500 kW per podded propulsion unit and for all ships, where it is necessary~~,~~ to meet the requirements of ~~*Pt 5, Ch 16, 3.1 General 3.1.4*~~ *Pt 5, Ch 9, 5.6 Steering system 5.6.5(b).*

~~6.6.3~~ 5.6.6 For vessels with more than one ~~steerable~~ podded propulsion unit, ~~the requirement for~~ auxiliary steering ~~arrangements~~ gear ~~in *Pt 5, Ch 19, 2 Performance* is to be achieved by equipping each of the podded propulsion units with its own dedicated and independent steering gear control system and power actuating system.~~ need not be fitted provided that each podded propulsion unit is capable of being supplied by two identical power units (the podded propulsion unit may be supplied by shared or dedicated power units) and:

(a) In cargo ships, each podded propulsion unit is capable of satisfying the requirements in *Pt 5, Ch 9, 5.6 Steering system 5.6.4(a)* while operating with all power units;
(b) In passenger ships, each podded propulsion unit is capable of satisfying the requirements in *Pt 5, Ch 9, 5.6 Steering system 5.6.4(a)* while any one of the power units is out of operation;

Each of the podded propulsion units is arranged so that after a single failure in its piping or in one of the power units, ship steering capability (but not individual steering system operation) can be maintained or speedily regained (e.g. by the possibility of positioning the failed steering system in a neutral position in an emergency, if needed). Consideration will be given to alternative arrangements providing equivalence can be demonstrated.

~~6.6.2 For vessels where a single podded propulsion unit is the sole means of propulsion, the requirement for auxiliary steering arrangements in *Pt 5, Ch 19, 2 Performance* is to be achieved by means of two or more identical power units.~~

~~3.1.3~~ 5.6.7 The steering ~~mechanism~~ gear for podded units used for ~~D~~dynamic ~~P~~positioning applications with an associated class notation, is to be capable of a rotational speed of not less than ~~1,5 rev/min~~ 9 deg/s.

Existing paragraph 6.6.4 has been renumbered 5.6.8.

~~6.6.5 The steering mechanism is to be provided with power that is sufficient for the maximum steering torques present during the declared functional capability identified in *Pt 5, Ch 9, 3.1 General*and is to be demonstrated for the most onerous specified manoeuvring trial, *see Pt 5, Ch 9, 9 Testing and trials*.~~

Existing paragraphs 6.6.6 to 6.6.8 have been renumbered 5.6.9 to 5.6.11.

~~6.6.9 On multi podded ships, means are to be provided to secure each pod unit's slewing mechanism in its mid position in the event of a steering system failure. These arrangements are to be of sufficient strength to hold the pod in position at the ship's manoeuvring speed to be taken as not less than 7 knots, *see also Pt 5, Ch 9, 6.3 Propulsion shafting 6.3.9*. Operating instructions displayed at the securing mechanism's operating position are to include a direction to inform the bridge of any limitation in ship's speed required as a result of the securing mechanism being activated.~~

Existing sub-Sections 6.7 to 6.9 have been renumbered 5.7 to 5.9.

Existing Sections 7 to 10 have been renumbered 6 to 9.

Part 5, Chapter 14
Machinery Piping Systems

■ *Section 2*
Fuel oil – General requirements

2.3 Fuel oil sampling

2.3.1 Sampling points are to be provided ~~at locations~~ within the fuel oil system. The design and location of sampling points is to ~~that~~ enable samples of fuel oil to be taken easily and in a safe manner.

2.3.2 The position of a sampling point is to be such that the sample of the fuel oil is representative of the fuel oil quality at ~~that~~ its location within the system, e.g. by ensuring steady state flow past the sampling point.

Note Samples taken from sounding pipes and tank drain cocks are not considered to be representative of the tank's contents.

2.3.3 Sampling points are to be located so as to reduce the possibility of fuel oil coming into contact with any heated surface or electrical equipment under reasonably foreseeable operating conditions and therefore shall be positioned as far away as possible from such surfaces or equipment. Where contact is still likely, positions are to be shielded from any heated surface or electrical equipment. The shielding shall be sturdy enough to endure leaks, splashes or spray under design pressure of the fuel oil supply line.

2.3.4 A sampling point or points shall be provided:

(a) Taking into account different fuel oil grades being used for the fuel oil combustion machinery item;

(b) Downstream of the in-use fuel oil service tank; and

(c) As close to the fuel oil combustion machinery as safely feasible taking into account the type of fuel oil, flow-rate, temperature, and pressure behind the selected sampling point.

~~2.3.3~~ 2.3.5 The sampling arrangements within the machinery space are to be capable of safely providing samples when the machinery is running and are to be provided with isolating valves and cocks of the self-closing type. ~~The sampling points are to be located in positions as far removed as possible from any heated surface or electrical equipment so as to preclude impingement of fuel oil onto such surfaces on equipment under all operating conditions, see *Pt 5, Ch 1, 3.7 Inclination of ship*.~~

■ *Section 4*
Fuel oil pumps, pipes, fittings, tanks, etc.

4.17 Separate fuel oil tanks

4.17.7 Separate fuel oil tanks may be permitted on the open deck in the cargo area of oil and chemical tankers subject to spill and fire safety considerations. Air and sounding pipes of separate fuel oil tanks are to comply with the requirements of *Pt 5, Ch 15, 2.5 Air and sounding pipes*.

Part 5, Chapter 16
Water jet systems

■ *Section 2*
General requirements

2.2 Plans to be submitted

2.2.1 Plans~~, in triplicate,~~ and information as detailed below and in *Pt 5, Ch 16, 2.3 Calculations and information* and *Pt 5, Ch 16, 2.4 Failure Mode and Effects Analysis (FMEA)*, are to be submitted for consideration.

2.2.5 The declared steering angle limits are to be stated by the manufacturer for each steerable water jet system.

■ *Section 3*
Design requirements

3.7 Nozzle/steering arrangements

3.7.1 ~~In general, the steering systems and components are to comply with the~~ The requirements of *Pt 5, Ch 19 Steering ~~Arrangements~~ Systems* are to be complied with where applicable. ~~The requirements of *Pt 5, Ch 19, 2.1 General 2.1.2* and *Pt 5, Ch 19, 2.1 General 2.1.2* are addressed by *Pt 5, Ch 16, 3.7 Nozzle/steering arrangements 3.7.3* and the requirements of *Pt 5, Ch 19, 2.1 General 2.1.3* and *Pt 5, Ch 19, 2.1 General 2.1.3* are addressed by *Pt 5, Ch 16, 3.7 Nozzle/steering arrangements 3.7.4.*~~

3.7.2 Where more than one steerable water jet is fitted, *Pt 5, Ch 19, 2.1 Performance 2.1.2* is considered to be met when:

(a) Each steerable water jet fulfils the requirements for main steering gear (*see Pt 5, Ch 16, 3.7 Nozzle/Steering arrangements 3.7.3*), and

(b) Each of the steering systems is provided with the ability to position and lock the steerable water jet in a neutral position after a failure of its power unit(s) and actuator(s). These arrangements are to be of sufficient strength to hold the steerable water jet in position at the ship's manoeuvring speed to be taken as not less than 7 knots. Operating instructions displayed at the locking mechanism's operating position are to include a direction to inform the bridge of any limitation in ship's speed required as a result of the securing mechanism being activated.

3.7.3 The main steering ~~arrangements are~~ gear is to be ~~operated by power and capable of changing the direction of the ship's water jet nozzles from one side to the other at declared steering angle limits at an average rotational speed of not less than 0,4 rev/min, with the ship running ahead at maximum ahead service speed.~~:

(a) Of adequate strength and capable of changing direction of the steerable water jet from one side to the other in accordance with the declared steering angle limits at an average rotational speed of not less than 2,3 deg/s with the ship running ahead at maximum ahead service speed which shall be demonstrated in accordance with *Pt 5, Ch 19, 7.2 Trials*; and

(b) Operated by power; and

(c) So designed that they will not be damaged at maximum astern speed.

3.7.4 The auxiliary steering ~~arrangements are~~ gear is to be:

(a) Capable of being brought speedily into action in an emergency; and

~~(a)~~(b) Of adequate strength and ~~C~~capable of changing the direction of the ship's water jet nozzles from one side to the other ~~at~~ in accordance with the declared steering angle limits at an average rotational speed of not less than ~~0,083 rev/min~~ 0,5 deg/s, with the ship running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater~~.~~; and

~~(b)~~(c) Operated by power for ships having propulsion power of more than 2500 kW per water jet unit and for all ships, where it is necessary~~,~~ to meet the requirements of *Pt 5, Ch 16, 3.7 Nozzle/steering arrangements 3.7.4(b).*

~~3.7.2~~ 3.7.5 For vessels with more than one steerable water jet, ~~the requirement for~~ auxiliary steering ~~arrangements~~ gear ~~in *Pt 5, Ch 19, 2 Performance* is to be achieved by equipping each of the steerable water jets with its own dedicated and independent steering gear control system and power actuating system.~~ need not be fitted provided that each steerable water jet is capable of being supplied by two identical power units (the steerable water jet may be supplied by shared or dedicated power units) and:

(a) In cargo ships, each steerable water jet is capable of satisfying the requirements in *Pt 5, Ch 16, 3.7 Nozzle/steering arrangements 3.7.3(a)* while operating with all power units;

(b) In passenger ships, each steerable water jet is capable of satisfying the requirements in *Pt 5, Ch 16, 3.7 Nozzle/steering arrangements 3.7.3(a)* while any one of the power units is out of operation;

Each of the steerable water jets is arranged so that after a single failure in its piping or in one of the power units, ship steering capability (but not individual steering system operation) can be maintained or speedily regained (e.g. by the possibility of positioning the failed steering system in a neutral position in an emergency, if needed). Consideration will be given to alternative arrangements providing equivalence can be demonstrated.

Existing paragraphs 3.7.5 to 3.7.8 have been renumbered 3.7.6 to 3.7.9.

Part 5, Chapter 19
Steering ~~Arrangements~~ Systems

■ Section 1
General

1.1 Application

1.1.1 The requirements of this Chapter apply to the design and construction of steering ~~arrangements~~ systems.

1.2 Definitions

1.2.9 ~~**Steering arrangements** means the complete system of components for providing ship directional control.~~ **Steering system** means a complete system of sub-systems and equipment capable of steering the ship including: the rudder (or podded propulsion unit, azimuth thruster, steerable water jet as applicable), main steering gear, auxiliary steering gear and steering gear control system.

~~1.2.10 **Directional control system** means the equipment used to effect changes in ship direction e.g. the rudder, podded propulsion unit, azimuth thrusters or water jet nozzle. Note that for podded propulsion systems, azimuth thrusters, water jet systems, or other similar systems for effecting changes in ship direction, it is to be assumed that the units must provide thrust in addition to rotation and hence the directional control system must include the propulsion system.~~

1.2.10 **Declared steering angle limits** are the operational limits in terms of maximum steering angle, or equivalent, according to manufacturer’s guidelines for safe operation, also taking into account the vessels speed or propeller torque/speed or other limitation.

1.5 Materials

1.5.1 All components used in the steering ~~arrangements~~ system ~~for ship directional control~~ are to be of sound reliable construction to the Surveyor’s satisfaction.

■ Section 2
Performance

2.1 General

2.1.1 Main and auxiliary steering gear for rudder-type steering systems are to meet the performance requirements in *Pt 5, Ch 19, 2.2 Performance requirements for rudder-type steering systems*. Steering performance on ships fitted with podded propulsion systems is to comply with *Pt 5, Ch 9, 5.6 Steering system* in addition to the requirements of this Chapter, as applicable. Steering performance on ships fitted with steerable water jet systems is to comply with *Pt 5, Ch 16, 3.7 Nozzle/steering arrangements* in addition to the requirements of this Chapter, as applicable. Steering performance on ships fitted with azimuth thruster systems is to comply with *Pt 5, Ch 21, 2.1 General* in addition to the requirements of this Chapter, as applicable.

Existing paragraph 2.1.1 has been renumbered 2.1.2.

Existing paragraphs 2.1.2 to 2.1.4 have been moved to new sub-Section 2.2.

Existing paragraphs 2.1.5 to 2.1.9 have been renumbered 2.1.3 to 2.1.7.

2.2 Performance requirements for rudder-type steering systems

~~2.1.2~~ 2.2.1 The main steering ~~arrangements for ship directional control are~~ gear is to be:

(a) Of adequate strength and capable of ~~steering the ship at maximum ahead service speed which shall be demonstrated in accordance with *Pt 5, Ch 19, 7.2 Trials*;~~

~~(b)~~ ~~Capable of~~ putting the rudder over from 35° on one side to 35° on the other side with the ship at its deepest sea-going draught and running ahead at maximum ahead service speed and under the same conditions, from 35° on either side to 30° on the other side in not more than 28 seconds~~.~~ which shall be demonstrated in accordance with *Pt 5, Ch 9, 9 Testing and trials*; and

~~(c)~~(b) Operated by power where necessary to meet the requirements of ~~*Pt 5, Ch 19, 2.1 General 2.1.2*~~ *Pt 5, Ch 19, 2.2 Performance requirements for rudder-type steering systems 2.2.1(a)* and in any case when the Rules excluding strengthening for navigation in ice, require a rudder stock over 120 mm diameter in way of the tiller; and

~~(d)~~(c) So designed that they will not be damaged at maximum astern speed; however, this design requirement need not be proved by trials at maximum astern speed and maximum rudder angle.

~~2.1.3~~2.2.2 The auxiliary steering ~~arrangements for ship directional control are~~ gear is to be:

(a) ~~Of adequate strength and c~~Capable of ~~steering the ship at navigable speed and of~~ being brought speedily into action in an emergency; and

(b) Of adequate strength and ~~C~~capable of putting the rudder over from 15° on one side to 15° on the other side in not more than 60 seconds with the ship at its deepest sea-going draught and running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater; and

(c) Operated by power where necessary to meet the requirements of ~~*Pt 5, Ch 19, 2.1 General 2.1.3*~~ *Pt 5, Ch 19, 2.2 Performance requirements for rudder-type steering systems 2.2.2(b)* and in any case when the Rules, excluding strengthening for navigation in ice, require a rudder stock over 230 mm diameter in way of the tiller.

~~2.1.4~~ 2.2.3 Where the main steering ~~arrangements for ship directional control~~ gear comprises two or more identical power units, auxiliary steering arrangements need not be fitted, provided that:

(a) In cargo ships, the main steering gear is capable of operating the ship's rudder as required by *Pt 5, Ch 19, 2.2 Performance requirements for rudder-type steering systems 2.2.1(a)* while operating with all power units;

~~(a)~~(b) In ~~a~~ passenger ships, the main steering ~~arrangements are~~ gear is capable of operating the ship's ~~directional control system~~ rudder as required by ~~*Pt 5, Ch 19, 2.1 General 2.1.2*~~ *Pt 5, Ch 19, 2.2 Performance requirements for rudder-type steering systems 2.2.1(a)* while any one of the power units is out of operation;

~~(b)~~ ~~In a cargo ship, the main steering arrangements are capable of operating the ship's directional control system as required by *Pt 5, Ch 19, 2.1 General 2.1.2* while operating with all power units;~~

(c) The main steering ~~arrangements~~ gear are arranged so that after a single failure in its piping system or in one of the power units the defect can be isolated so that steering capability can be maintained or speedily regained.

Existing sub-Section 2.2 has been renumbered 2.3.

■ *Section 4*

Steering control systems

4.1 General

4.1.1 The steering control system is to comply with *Pt 6, Ch 1 Control Engineering Systems*.

Existing paragraphs 4.1.1 to 4.1.4 have been renumbered 4.1.2 to 4.1.5.

~~4.1.5~~ 4.1.6 Arrangements for failure detection are to be provided with self-monitoring capabilities. In the event of failure being detected, an audible and individual visual alarm is to be initiated on the navigating bridge. *See Pt 5, Ch 19, 5.3 Monitoring and alarms*. Where the system failure alarms for hydraulic lock, *see Table 19.5.1 Alarms*, are provided, appropriate instructions ~~shall~~ are to be placed on the navigating bridge to shut down the system at fault.

4.1.7 In the event of detecting a control system failure, which is likely to cause uncontrolled rudder movements, *see Table 19.5.1 Alarms*, the rudder is to retain its position at the time of failure. Alternatively, consideration will be given to the rudder moving to and retaining a position which is necessary for safe navigation of the vessel or to return to the mid-ship position where technical justification is submitted and is found to be satisfactory.

■ *Section 5*

Electric power circuits, electric control circuits, monitoring and alarms

5.1 Electrical power circuits

5.1.1 In addition to this section, the control and electrical installation is to comply with *Pt 6, Ch 1 Control Engineering Systems* and *Pt 6, Ch 2 Electrical Engineering*.

Existing paragraphs 5.1.1 to 5.1.10 have been renumbered 5.1.2 to 5.1.11.

5.1.12 For a ship fitted with multiple steering systems, *Pt 5, Ch 19, 5.1 Electric power circuits 5.1.7* to *Pt 5, Ch 19, 5.1 Electric power circuits 5.1.11* are to be applied to each of the steering systems.

Existing paragraph 5.1.11 has been renumbered 5.1.13.

5.3 Monitoring and alarms

Table 19.5.1 Alarms ~~requirements~~

Item	Alarm	Note
Rudder position	—	Indication, *see Pt 5, Ch 19, 4.1 General 4.1.3*
	Failure	*See Pt 5, Ch 19, 5.3 Monitoring and alarms 5.3.3*
Earthing on AC and DC circuits	Fault	If galvanically isolated from the ship's network
Data communication	Error	Where the data deviates from expected value, sequence or timing
Steering gear power units, power	Failure	—
Steering gear motors	Overload, Single phase	For alarm and running indication locations, *see Pt 5, Ch 19, 5.1 Electric power circuits 5.1.3* and *Pt 5, Ch 19, 5.1 Electric power circuits 5.1.4*
Control system	Failure	*See Pt 5, Ch 19, 5.3 Monitoring and alarms 5.3.3*
Control system power	Failure	—
Steering gear hydraulic oil tank level	Low	Each reservoir to be monitored. For alarm locations, *see Pt 5, Ch 19, 5.1 Electric power circuits 5.1.5*
Auto pilot	Failure	Running indication
Hydraulic oil temperature	High	Where oil cooler is fitted
Hydraulic lock	Fault	Where more than one system (either power or control) can be operated simultaneously each system is to be monitored, *see* Note
Hydraulic oil filter differential pressure	High	When oil filters are fitted

~~**NOTE**~~ Note

This alarm is to identify the system at fault and to be activated when (for example):

- position of the variable displacement pump control system does not correspond with given order; or
- incorrect position of 3-way full flow valve or similar in constant delivery pump system is detected.

■ *Section 6*
Emergency power

6.1 General

6.1.1 The requirements of *Pt 5, Ch 19, 6.1 General* apply to steering systems with:

(a) A rudder-type steering system where the rudder stock is required to be over 230 mm diameter in way of the tiller, excluding strengthening for navigation in ice; or

(b) Podded propulsion units or steerable water jet systems where the power per propulsion unit exceeds 2,500 kW and the podded propulsion unit or steerable water jet has a proven steering capability due to vessel velocity even when propulsion power has failed.

~~6.1.1~~ 6.1.2 ~~Where the rudder stock is required to be over 230 mm diameter in way of the tiller, excluding strengthening for navigation in ice, or for ships fitted with podded propulsion units or water jet systems where the power per propulsion unit exceeds 2,500 kW, an~~ An alternative power supply, sufficient at least to supply the steering ~~arrangements~~ system which comply with the requirements of *Pt 5, Ch 19, 2.1 General 2.1.3* and also its associated control system and the steering angle indicator, is to be provided automatically, within 45 seconds, either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment. This independent source of power shall be used only for this purpose.

Existing paragraphs 6.1.2 and 6.1.3 have been renumbered 6.1.3 and 6.1.4.

■ *Section 7*
Testing and trials

7.2 Trials

(*Part only shown*)

7.2.1 The steering gear is to be ~~tried out~~ tested on the trial trip in order to demonstrate to the Surveyor's satisfaction that the requirements of the Rules have been met. The trial is to include the operation of the following:

(a) The steering gear, including demonstration of the performances required by: ~~*Pt 5, Ch 19, 2.1 General 2.1.2.(b)*~~ *Pt 5, Ch 19, 2.2 Performance requirements for rudder-type steering systems 2.2.1(a)* and ~~*Pt 5, Ch 19, 2.1 General 2.1.3.(b)*~~ *Pt 5, Ch 19, 2.2 Performance requirements for rudder-type steering systems 2.2.2(b)* where a rudder type steering system is fitted, or by *Pt 5, Ch 9, 5.6 Steering system 5.6.4 (a) and Pt 5, Ch 9, 5.6 Steering system 5.6.5 (b)* where a podded propulsion steering system are fitted, or by *Pt 5, Ch 16, 3.7 Nozzle/steering arrangements 3.7.3(a) and Pt 5, Ch 16, 3.7 Nozzle/steering arrangements 3.7.4(b)* where water jets steering system is, or by *Pt 5, Ch 20, 2.1 General 2.1.~~4~~(a)Pt 5, Ch 20, 2.1 General 2.1.5(b)* where an azimuth thruster steering system is fitted:

Part 5, Chapter 20
Azimuth Thrusters

■ *Section 1*
General requirements

1.2 Plans

1.2.2 The declared steering angle limits are to be stated by manufacturer for each azimuth thruster.

■ *Section 2*
Performance

2.1 General

2.1.1 ~~The arrangement of thrusters is to be such that the ship can be satisfactorily manoeuvred.~~ The arrangement of azimuth thrusters is to be such that the ship can be satisfactorily manoeuvred to a declared performance capability. The operating conditions covered are to include the following:

(a) Maximum continuous shaft power/speed to the propeller in the ahead condition at the declared steering angles and conditions.

(b) Manoeuvring speeds of the propeller shaft and/or reversing mechanism in the ahead and astern direction at the declared steering angles and sea conditions.

(c) The stopping manoeuvre described in *Pt 5, Ch 1, 5.2 Sea trials 5.2.2*.

(d) Astern running conditions for the ship.

~~2.1.3~~ 2.1.2 ~~In general, the steering systems and components are to comply with the~~ The requirements of *Pt 5, Ch 19 Steering Arrangements* are to be complied with where applicable. ~~The requirements of *Pt 5, Ch 19, 2.1 General 2.1.2* and *Pt 5, Ch 19, 2.1 General 2.1.2* are addressed by *Pt 5, Ch 20, 2.1 General 2.1.5* and the requirements of *Pt 5, Ch 19, 2.1 General 2.1.3* and *Pt 5, Ch 19, 2.1 General 2.1.3* are addressed by *Pt 5, Ch 20, 2.1 General 2.1.6*.~~

2.1.3 Where more than one azimuth thruster is fitted, *Pt 5, Ch 19, 2.1 Performance 2.1.2* is considered to be met when:

(a) Each azimuth thruster fulfils the requirements for main steering gear (*see Pt 5, Ch 20, 2.1 General 2.1.4*); and

(b) Each azimuth thruster is provided with the ability to position and lock the azimuth thruster in a neutral position after a failure of its own power unit(s) and actuator(s). These arrangements are to be of sufficient strength to hold the azimuth thruster in position at the ship's manoeuvring speed to be taken as not less than 7 knots. Operating instructions displayed at the locking mechanism’s operating position are to include a direction to inform the bridge of any limitation in ship's speed required as a result of the securing mechanism being activated.

~~2.1.5~~ 2.1.4 The main steering ~~arrangements are~~ gear is to be ~~operated by power and capable of changing the direction of the ship’s azimuth thrusters from one side to the other at declared steering angle limits at an average rotational speed of not less than 0,4 rev/min, with the ship running ahead at maximum ahead service speed.~~:

(a) Of adequate strength and capable of changing direction of the azimuth thruster from one side to the other in accordance with the declared steering angle limits at an average rotational speed of not less than 2,3 deg/s with the ship running ahead at maximum ahead service speed which shall be demonstrated in accordance with *Pt 5, Ch 9, 9 Testing and trials*; and

(b) Operated by power; and

(c) So designed that they will not be damaged at maximum astern speed.

~~2.1.6~~ 2.1.5 The auxiliary steering ~~arrangements are~~ gear is to be:

(a) Capable of being brought speedily into action in an emergency; and

~~(a)~~(b) Of adequate strength and ~~C~~capable of changing the direction of the ship's azimuth thrusters from one side to the other ~~at~~ in accordance with the declared steering angle limits at an average rotational speed of not less than ~~0,083 rev/min~~ 0,5 deg/s, with the ship running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater~~.~~; and

~~(b)~~(c) Operated by power for ships having propulsion power of more than 2500 kW per thruster unit and for all ships, where it is necessary~~,~~ to meet the requirements of ~~*Pt 5, Ch 20, 2.1 General 2.1.6*~~ *Pt 5, Ch 20, 2.1 General 2.1.5(b)*.

~~2.1.2~~ 2.1.6 For vessels with ~~multiple~~ more than one azimuthing thruster~~s~~, ~~the requirement for~~ auxiliary steering ~~arrangements~~ gear ~~in *Pt 5, Ch 19, 2 Performance* is to be achieved by equipping each of the azimuthing thrusters with its own dedicated and independent steering gear control system and power actuating system. Consideration will be given to alternative arrangements providing equivalence can be demonstrated.~~ need not be fitted provided that each azimuth thruster is capable of being supplied by two identical power units (the azimuth thruster may be supplied by shared or dedicated power units) and:

(a) In cargo ships, each azimuth thruster is capable of satisfying the requirements in *Pt 5, Ch 20, 2.1 General 2.1.4(a)* while operating with all power units;

(b) In passenger ships, each azimuth thruster is capable of satisfying the requirements in *Pt 5, Ch 20, 2.1 General 2.1.4(a)* while any one of the power units is out of operation.

Each of the azimuth thrusters is arranged so that after a single failure in its piping or in one of the power units, ship steering capability (but not individual steering system operation) can be maintained or speedily regained (e.g. by the possibility of positioning the failed steering system in a neutral position in an emergency, if needed). Consideration will be given to alternative arrangements providing equivalence can be demonstrated.

~~2.1.4~~ 2.1.7 ~~In addition to the requirements of *Pt 5, Ch 19 Steering Arrangements*, the azimuthing mechanism~~ The steering ~~system~~ gear for azimuth thrusters used for dynamic positioning applications with an associated class notation, is to be capable of a rotational speed of not less than ~~1,5 rev/min~~ 9 deg/s.

Part 5, Chapter 24
Emissions Abatement Plant for Combustion Machinery

■ *Section 1*
General

1.2 Class notation and descriptive note

1.2.1 Ships complying with the relevant requirements of this Chapter will be eligible for assignment of the **EGCS()** machinery notation. This notation is to be assigned with one of the following associated notations depending on the type of SO_x emissions abatement plant that is installed on board:

(Open)	Open loop wet scrubber installed with no capacity to operate in zero discharge mode;
(Closed)	Closed loop wet scrubber installed only capable of operating in zero discharge mode;
(Hybrid)	The installed wet scrubber is able to operate in both open loop and closed loop modes; or
(Dry)	Dry scrubber installed.

The **EGCS()** notation indicates that the SO_x emissions abatement plant has been designed, constructed, arranged, installed and tested in accordance with LR's Rules and Regulations. Application of the **EGCS()** notation does not infer that the installation meets applicable statutory emissions regulations. Where the installed SO_x emissions abatement plant is not intended to reduce the emissions produced by all fuel oil combustion machinery excluding shipboard incinerators fitted on board that are required to comply with statutory emissions regulations, the notation '**Partial**' is to be appended to the **EGCS** notation, e.g. **EGCS(Open, Partial)**.

1.2.2 Ships complying with particular requirements of this chapter may be eligible for the Exhaust Gas Cleaning System Ready (**EGCS-R()**) descriptive note. This descriptive note may be assigned when aspects of design and construction are prepared for installation of SO_x emissions abatement plant for combustion machinery. This is not an LR class notation and is provided solely for information.

EGCS-R() Assigned to ships with the extension of one or more of the following associated characters shown in brackets, detailing the aspects of design and construction that are in accordance with LR's Rules and Regulations in force on the date of 'contract for construction':

A Preliminary assessment of the proposed SO_x emissions abatement system including its arrangement on board has been completed satisfactorily;

S Enhanced structural reinforcement and structural modifications necessary for the function of the proposed SO_x emissions abatement plant have been fitted under survey. For open loop systems this includes any necessary enlargement of sea chests and fitting of additional sea water inlets for future use;

T The relevant tank(s) needed for operation of the proposed SO_x emissions abatement system (e.g. chemical and/or residue storage tanks as applicable) have been installed under survey in accordance with approved design.

Where the proposed SO_x emissions abatement plant is not intended to reduce the emissions produced by all fuel oil combustion machinery excluding shipboard incinerators fitted on board that are required to comply with statutory emissions regulations, the notation '**Partial**' is to be appended to the **EGCS** descriptive note, e.g. **EGCS-R(A, Partial)**. Further appraisal against the LR requirements at the time of installation followed by testing under survey will be required when the emissions abatement plant is to be installed. Application of the **EGCS-R()** descriptive note does not infer that the proposed installation will meet the statutory requirements for emissions regulation.

1.2.3 The following are to be submitted to achieve SR descriptive note with applicable associated characters:

(a) **EGCS-R(A)** 'Preliminary assessment'
- Vessel general arrangement;
- General arrangement of SO_x emissions abatement plant illustrating the locations of SO_x emissions abatement machinery and tanks with respect to machinery, control and service spaces;
- Exhaust system arrangement (showing necessary modifications for installation of the proposed SO_x emissions abatement system);
- Arrangement and capacity of tanks for storage of chemicals, sludge and residue as necessary;
- Information on the operational requirements of the proposed SO_x emissions abatement plant with respect to sea water demand and additional chemical requirements as applicable;
- Electrical system requirements including details of how the proposed system is to be incorporated into the vessels electrical system; and
- Preliminary studies for vessel loadline and stability taking the proposed SO_x emissions abatement plant installation into account.

(b) **EGCS-R(S)** 'Structural reinforcement fitted'
- Full details of the structural reinforcement required to support the proposed emissions abatement plant are to be submitted. This should include details of the proposed plant type, size, location and loadings (dynamic and static) to allow verification of the submitted structural design and calculations for the plant support arrangements.

(c) **EGCS-R(T)** 'Tank installed'
- Plans and information required for **EGCS-R(S)** descriptive note;
- Structural plans for tanks to be installed in accordance with *Pt 3, Ch 1, 2 Direct calculations*;
- Full details of the materials proposed for construction of the tank(s);
- Details of the flammability, toxicity, corrosivity and reactivity of any chemicals to be stored in the tanks. This is to include effluent and sludge associated with emissions abatement plant, and the corrosivity of wash water for wet scrubbing systems;
- Details of air and sounding pipes to tanks containing chemicals, substances and effluent; and
- Details of arrangements for loading, storage, transfer and disposal of chemicals, by-products or waste products. This is to include allowable maximum and minimum storage temperatures for substances which are sensitive to temperature.

Part 6, Chapter 1
Control Engineering Systems

■ *Section 1*
General requirements

1.2 Documentation required for design review

1.2.2 Where control, alarm, monitoring and safety systems are intended for the machinery or equipment as defined in *Pt 6, Ch 1, 1.2 Documentation required for design review 1.2.3* the following are to be submitted:

- Description of operation with explanatory diagrams.
- Line diagrams of control circuits.
- List of monitored points.
- List of control points.
- Details of alarms and warnings to be presented by the user interface, including:
- an approach to category assignments which is in accordance with the IMO *Code on Alerts and Indicators, 2009-*; and
- (ii) for alarms required by these Rules, the intended operator response and the message to be presented.
- Test schedules (for both works testing and sea trials) which should include methods of testing (for example, simulation testing) and test facilities provided, *see Pt 6, Ch 1, 1.3 Control, alarm and safety equipment 1.3.1.*
- Failure Mode and Effects Analysis (FMEA) where required by other sections of the Rules.
- List of safety functions and details of any overrides, including consequences of use, *see Pt 6, Ch 1, 2.4 Safety systems, general requirements 2.4.8* and *Pt 6, Ch 1, 2.6 Bridge control for main propulsion machinery 2.6.8*.

1.2.3 Plans for the control, alarm, monitoring and safety systems of the following are to be submitted:

- Air compressors.
- Bilge and ballast systems.
- Cargo pumping systems for tankers.
- Cargo and ballast pumps in hazardous areas.
- Cargo tank, cargo hold, ballast tank and void space instrumentation where such arrangements are specified by other sections of the Rules (e.g. water ingress detection, gas detection).
- Controllable pitch propellers.
- Electric generating plant.
- Fixed water based local application fire-fighting systems, *see Pt 6, Ch 1, 2.9 Fixed water-based local application fire-fighting systems.*
- Incinerators.
- Inert gas generators.
- Main propelling machinery including essential auxiliaries.
- Miscellaneous machinery or equipment (where control, alarm, monitoring and safety systems are specified by other Sections of the Rules).
- Fuel oil transfer and storage systems.
- Steam raising plant. (Boilers and their ancillary equipment.)
- Steering gear.
- Thermal fluid heaters.
- Transverse thrust units.
- Valve position indicating systems.
- Waste-heat boiler.
- Waterjets for propulsion purposes.
- Windlasses.

1.2.4 **System operational concept.** A description of the intended operation of the control, alarm, monitoring and safety systems for the main and auxiliary machinery, and other systems essential for the propulsion and safety of the ship. This description is to include a demonstration that the design provides an effective means of operation and control for all ship operating conditions.

1.6 Definitions

1.6.12 Sub-system: identifiable part of a system, which may perform a specific function or set of functions.

1.6.13 Programmable electronic equipment: physical component where software is installed.

1.6.14 Software module: a module is a standalone piece of code that provides specific and closely coupled functionality.

1.6.15 Simulation tests: system testing where simulation tools replace parts or all of the equipment, or where parts of the communication network and lines are replaced with simulation tools.

■ *Section 2*
Essential features for control, alarm, monitoring and safety systems

2.10 Programmable electronic systems – General requirements

2.10.1 The requirements of this sub-section are to be complied with where control, alarm, monitoring or safety systems incorporate programmable electronic equipment. Systems for essential services and safety critical applications, systems incorporating shared data communication links and systems which are integrated are to comply with the additional requirements of *Pt 6, Ch 1, 2.11 Data communication links*, *Pt 6, Ch 1, 2.13 Programmable electronic systems - Additional requirements for essential services and safety critical* ~~*systems*and~~ *systems* and *Pt 6, Ch 1, 2.14 Programmable electronic systems – Additional requirements for integrated systems* as applicable. For systems complying with ISO 17894, *Ships and marine technology – Computer applications – General principles for the development and use of programmable electronic systems in marine applications*, *see Pt 6, Ch 1, 2.12 Additional requirements for wireless data communication links*.

2.10.13 Access to system configuration, programs and data is to be restricted by physical and/or logical means providing effective security against unauthorised alteration, both for local and remote access.

2.10.20 Software lifecycle activities, e.g. design, development, supply and maintenance, are to be carried out in accordance with an acceptable quality management system which has lifecycle models suitable to the nature of the software project, considering its size, complexity, safety, risk and integrity. Project specific software quality plans are to be submitted. These are to demonstrate that the provisions of ISO/IEC 90003: Software engineering – *Guidelines for the application of ISO 9001:200~~0~~8 to computer software*, or equivalent, are incorporated. The plans are to define responsibilities for the lifecycle activities, including verification, validation, software module testing ~~and~~, integration with other components or systems and security policies to be applied.

2.13 Programmable electronic systems – Additional requirements for essential services and safety critical systems

2.13.1 The requirements of *Pt 6, Ch 1, 2.13 Programmable electronic systems - Additional requirements for essential services and safety critical systems 2.13.2*~~to~~ to *Pt 6, Ch 1, 2.13 Programmable electronic systems - Additional requirements for essential services and safety critical systems 2.13.10* are to be complied with where control, alarm, monitoring or safety systems for essential services, as defined by *Pt 6, Ch 2, 1.6 Definitions*, or safety critical systems, incorporate programmable electronic equipment.

(a) Safety critical systems are those which provide functions intended to protect persons from physical hazards (e.g. fire, explosion, etc.), or to prevent mechanical damage which may result in the loss of an essential service (e.g. main engine low lubricating oil pressure shutdown).

(b) Applications that are not essential services may also be considered to be safety critical (e.g. domestic boiler low water level shutdown).

■ *Section 7*
Trials

7.1 General

7.1.5 Before installation of programmable electronic systems programs, data and the physical medium used for installation on the vessel are to be scanned for viruses and malicious software. Results of the scan are to be documented, kept with the software registry and be available to the Surveyor on request.

Part 6, Chapter 2
Electrical Engineering

■ *Section 1*
General requirements

1.2 Documentation required for design review

(*Part only shown*)

1.2.3 A functional description of operation of the main, emergency and transitional electrical power systems, which is to include:

(c) load management and load sharing philosophy; ~~and~~

(e) harmonic filters where fitted, including harmonic analysis, the permitted modes of operation for maintaining the harmonic distortion within acceptable limits, and the effect on harmonic distortion of the failure of any combination of harmonic filters, *see also Pt 6, Ch 2, 1.8 Quality of power supplies 1.8.3* and *Pt 6, Ch 2, 1.8 Quality of power supplies 1.8.4*; and

(f) guidance indicating the safe operating modes of the electrical power system under both normal and failure conditions of the harmonic filters where fitted.

(*Part only shown*)

1.2.10 For ships with electrical propulsion systems, a functional description is to be provided which includes:

(e) harmonic analysis, including loss of harmonic filters. *See also Pt 6, Ch 2, 1.2 Documentation required for design review 1.2.3* and *Pt 6, Ch 2, 1.8 Quality of power supplies 1.8.3* and *Pt 6, Ch 2, 1.8 Quality of power supplies 1.8.4*.

(*Part only shown*)

1.2.11 Simplified circuit diagram of electrical propulsion system (where fitted) giving details of:

(h) harmonic filters and analysis.

1.7 Design and construction

1.7.4 Permanently installed electrical and electronic equipment that are capable of generating electromagnetic interference, which can interfere with the proper functionality of essential services or services upon which they depend, are to be designed, constructed and installed in accordance with the guidelines and recommendations of one of the following standard(s), as appropriate to its location:

(a) IEC 60533 - *Electrical and electronic installations in ships - Electromagnetic compatibility (EMC)*; or
(b) IEC 60945 - *Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results*; or
(c) LR Type Approval System – Test Specification Number 1;
(d) Alternative national or international standard(s) acceptable to LR.

Existing paragraph 1.7.4 has been renumbered 1.7.5.

1.8 Quality of power supply

1.8.3 ~~Harmonics.~~ Unless specified otherwise, the total harmonic distortion (THD) of the voltage waveform at any a.c switchboard or section-board is not to exceed 8 per cent of the fundamental for all frequencies up to 50 times the supply frequency and no voltage at a frequency above 25 times supply frequency is to exceed 1,5 per cent of the fundamental of the supply voltage. THD is the ratio of the rms value of the harmonic content to the rms value of the fundamental, expressed in per cent and may be calculated using the expression:

$$THD = \frac{\sqrt{\sum_{h=2}^{\infty} V_h^2}}{V_1} \times 100$$

where
V_h = rms amplitude of a harmonic voltage of order h
V_1 = rms amplitude of the fundamental voltage.

1.8.4 Where a higher value of THD is specified, all installed equipment and systems are to be designed for the higher specified limit. This relaxation on the limit is to be documented in the harmonic distortion calculation report.

Existing paragraph 1.8.4 has been renumbered 1.8.5.

1.12 Earthing of non-current carrying parts

1.12.1 Except where exempted by *Pt 6, Ch 2, 1.12 Earthing of non-current carrying parts 1.12.2*, all non-current-carrying exposed metal parts of electrical equipment and cables are to be earthed for ~~personal~~ personnel protection against electric shock. Bonding of non-current carrying exposed metal parts is to give a substantially equal potential and a sufficiently low earth fault loop impedance to ensure correct operation of protective devices.

1.19 Programmable electronic systems

1.19.1 Where programmable electronic systems are implemented and used to control the electrical installation, or to provide safety functions in accordance with the requirements of this Chapter (e.g. electric propulsion, circuit-breaker settings, switchgear and control gear controllers, etc.), the arrangements are to satisfy the applicable requirements of *Pt 6, Ch 1, 2.10 Programmable electronic systems - General requirements* to *Pt 6, Ch 1, 2.1~~3~~4 Programmable electronic systems - Additional requirements for ~~essential services and safety critical systems~~* integrated systems.

■ *Section 5*
Supply and distribution

5.10 Harmonic distortion measurement

5.10.1 The requirements of *Pt 6, Ch 2, 5.10 Harmonic distortion measurement* apply to electrical distribution systems that include harmonic filters. This requirement applies both to high voltage and low voltage busbars. *See also Pt 6, Ch 2, 6.13 Harmonic filters.* Harmonic filters associated with frequency drives for individual applications (i.e. pump motors) are excluded from the following requirements.

5.10.2 Means are to be provided to continuously monitor the levels of harmonic distortion experienced on the main busbars and to operate an alarm in the engine control room, or equivalent attended position, in the event that the harmonic distortion exceeds the acceptable limits, *see also Pt 6, Ch 1, 4.2 Alarm system for machinery.*

5.10.3 Where the engine room is provided with automation systems to continuously monitor the levels of harmonic distortion experienced on the main busbars, this reading is to be logged electronically; otherwise it is to be measured annually and after any modification to the craft electrical distribution system or associated consumers and recorded in the engine log book for future inspection by the Surveyor.

5.11 Harmonic filtering

5.11.1 The requirements in this Section apply to systems provided with harmonic filters. They apply in particular to, but are not limited to, electrical propulsion systems and are in addition to the requirements for harmonic filters in *Pt 6, Ch 2, 6.13 Harmonic filters.*

5.11.2 Filters used to control harmonic distortion are to keep the distortion within acceptable limits at the main supply. *See also Pt 6, Ch 2, 1.8 Quality of power supply.*

5.11.3 The service life of the harmonic filter is to be declared, and details are to be included in the harmonic calculation report.

5.11.4 The temperature rating of the harmonic filter is to allow for the increased heating effect of the harmonic distortion.

5.11.5 The construction of cabinets for harmonic filters shall be in accordance with the standards for main switchboards, where applicable. *See also Pt 6, Ch 2, 7 Switchgear and controlgear assemblies*.

5.11.6 The modes of operation of the electrical distribution system for which harmonic distortion levels at the main switchboard busbars are maintained within the acceptable limits during normal operation are to be defined by the system integrator.

5.11.7 Harmonic distortion calculations are to include levels of harmonic distortion expected in normal operation and in the event of a failure of a harmonic filter or the failure of any combination of harmonic filters. *See also Pt 6, Ch 2, 21.2 Trials.*

■ *Section 6*
System design – Protection

6.13 Harmonic filters

6.13.1 Harmonic filters' final sub-circuits are to be protected individually and individually on each phase against overload and short-circuit. The activation of the protection arrangement in a single phase shall result in automatic disconnection of the complete filter.

6.13.2 A current imbalance detection system is to be installed; it is to be independent from the protection specified in *Pt 6, Ch 2, 6.13 Harmonic filters 6.13.1*.

~~6.13.2~~ 6.13.3 An alarm is to be initiated in the event of protective device operation or current unbalance that could lead to failure of harmonic filter.

~~6.13.3 Where parallel harmonic filters are used:~~
~~(a) an alarm is to be initiated in the event of current imbalance that could lead to failure of a harmonic filter.~~
~~(b) current imbalance circuits are to 'fail safe'. The characteristics of the 'fail safe' operation are to be evaluated on the basis not only of the system and its associated machinery, but also the complete installation, as well as the ship;~~
~~(c) The restarting of harmonic filters is to require manual intervention.~~

6.13.4 Current imbalance circuits are to be 'fail safe'. The characteristics of the 'fail safe' operation are to be evaluated not only on the basis of the system and its associated machinery, but also the complete installation, as well as the ship.

6.13.5 The reconnection of harmonic filters is to require manual intervention.

6.13.6 Individual harmonic filter capacitors are to be provided with a pressure relief valve or overpressure disconnector to protect against damage from rupture where pressure build-up within hermetically sealed capacitors may occur.

■ *Section 14*

Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts

14.1 General

14.1.1 The installation of electrical equipment in spaces and locations in which flammable mixtures are liable to collect, e.g.~~,~~ areas containing flammable gas or vapour and/or combustible dust, is to be minimised~~ as far as is consistent with operational necessity and the provision of lighting, monitoring, alarm or control facilities enhancing the overall safety of the ship~~.

14.1.2 In order to eliminate potential sources of ignition from spaces and locations in which flammable mixtures are liable to collect~~, in accordance with *SOLAS - International Convention for the Safety of Life at Sea* as amended, *Chapter II-1, Regulation 45 - Precautions against shock, fire and other hazards of electrical origin (Paragraphs 10 and 11 of this regulation apply to ships constructed on or after 1 January 2007)*~~, such ~~dangerous or~~ hazardous areas are to be identified and electrical equipment within these areas is to be selected and installed in accordance with the requirements of this Section.

14.1.3 Spaces and locations are considered as hazardous in the presence of any of the following:

- (a) spaces or tanks containing either:
  - (i) flammable liquid having a flashpoint (closed-cup test) not exceeding 60°C and below;
  - (ii) flammable liquid having a flashpoint exceeding 60°C, heated or raised by ambient conditions to a temperature within 15°C of its flashpoint; or
  - (iii) flammable gas;
- (b) piping systems or equipment containing fluid defined by (a) and having flanged joints or glands or other openings through which leakage of fluid may occur under normal operating conditions;
- (c) spaces containing coal, grain or other solids liable to release flammable gas and/or combustible dust;
- (d) spaces containing dangerous goods in packaged form, of the following Classes as defined in the IMDG Code: 1 (with the exception of goods in division 1.4, compatibility group S), 2.1 (inclusive of applicable gas bottles for on board use), 3 (FP<23ºC), 6.1 (FP<23ºC) and 8 (FP<23ºC);
- (e) piping systems or equipment associated with processes (such as electro-chlorination) generating flammable gas as a by-product and having openings from which the gas may escape under normal operating conditions; or
- (f) piping systems or equivalent containing flammable liquids not defined by (a), having flanged joints, glands or other openings through which leakage of fluid in the form of a mist or fine spray may occur under normal operating conditions.

Note. FP means flashpoint (closed-cup test).

~~14.1.3~~ 14.1.4 Equipment that is to be installed in an area where ~~both~~ explosive gases ~~and combustible dusts~~ can be present is to be selected in accordance with *Pt 6, Ch 2, 14.3 Selection of equipment for use in explosive gas atmospheres*

14.1.5 Equipment that is to be installed in an area where combustible dusts can be present is to be selected in accordance with *Pt 6, Ch 2, 14.4 Selection of equipment for use in the presence of combustible dusts*.

14.1.6 For permanent secondary battery installations, *see Pt 6, Ch 2, 12 Batteries*.

~~14.5~~ 14.2 Hazardous ~~zones and spaces~~ areas

~~14.5.1~~ 14.2.1 Hazardous ~~zones or spaces~~ areas and sources of hazard for ships intended for the carriage in bulk of oil cargoes, liquefied gases, other flammable liquid cargoes, the special requirements for ships with spaces for carrying vehicles with fuel in their tanks for their own propulsion, the special requirements for ships intended for the carriage of dangerous goods and materials hazardous only in bulk and the requirements for ships with spaces for storing paint, are defined (either directly, or by reference to other documents) in *Pt 6, Ch 2, 14.10 Requirements for tankers intended for the carriage in bulk of oil cargoes having a flash point not exceeding 60°C (closed-cup test)* to *Pt 6, Ch 2, 14.15 Requirements for ships with spaces for storing paint Pt 6, Ch 2, 14.15 Requirements for ships with spaces for storing paint* .

~~14.5.2~~ 14.2.2 Hazardous areas associated with flammable liquids or gases are classified into zones based upon the frequency of the occurrence and duration of an explosive gas atmosphere, as follows:

- **zone 0**: ~~place~~ an area in which an explosive atmosphere ~~consisting of a mixture with air of flammable substances in the form of gas, vapour or mist~~ is present continuously or for long periods or frequently
- **zone 1**: ~~place~~ an area in which an explosive atmosphere is likely to occur periodically or occasionally in normal operation
- **zone 2**: ~~place~~ an area in which an explosive atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

See IEC 60079-10-1: *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres.~~.~~*

~~14.5.2~~ 14.2.3 Hazardous areas associated with solid substances or packaged liquids to which *Pt 6, Ch 2, 14.14 Special requirements for ships intended for the carriage of dangerous goods and materials hazardous only in bulk* applies are classified into zones based upon the frequency of the occurrence and duration of an explosive atmosphere due to the presence of gas and/or combustible dust, as follows:

- **hazardous area**: area in which an explosive atmosphere is likely to occur in normal operation (comparable with **zone 1**)
- **extended hazardous area**: area in which an explosive atmosphere is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only (comparable with **zone 2**).

See ~~IEC 60079-10-2: *Explosive atmospheres — Part 10-2: Classification of areas – Combustible dust atmospheres*, or~~ IEC 60092-506: *Electrical Installation in ships – Part 506: Special features – Ships carrying specific dangerous goods and materials hazardous only in bulk*. An explosive atmosphere may exist due to gas and/or combustible dust.

~~14.5.4 The following principles are to apply in general, and where any specific arrangement does not fall into any of the categories covered by *Pt 6, Ch 2, 14.10 Requirements for tankers intended for the carriage in bulk of oil cargoes having a flash point not exceeding 60°C (closed-cup test)* to *Pt 6, Ch 2, 14.15 Requirements for ships with spaces for storing paint*.~~

~~14.5.5 A hazardous zone or space may arise from the presence of any of the following:~~
~~(a) spaces or tanks containing either:~~
  ~~(i) flammable liquid having a flashpoint (closed-cup test) not exceeding 60°C and below;~~
  ~~(ii) flammable liquid having a flashpoint exceeding 60°C, heated or raised by ambient conditions to a temperature within 15°C of its flashpoint; or~~
  ~~(iii) flammable gas;~~
~~(b) piping systems or equipment containing fluid defined by (a) and having flanged joints or glands or other openings through which leakage of fluid may occur under normal operating conditions;~~
~~(c) spaces containing solids, such as coal or grain, liable to release flammable gas and/or combustible dust;~~
~~(d) spaces containing dangerous goods in packaged form, of the following Classes as defined in the IMDG Code: 1 (with the exception of goods in division 1.4, compatibility group S), 2.1 (inclusive of applicable gas bottles for on board use), 3, 6.1 and 8;~~
~~(e) piping systems or equipment associated with processes (such as electrochlorination) generating flammable gas as a by-product and having openings from which the gas may escape under normal operating conditions; or~~
~~(f) piping systems or equivalent containing flammable liquids not defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(a)*, having flanged joints, glands or other openings through which leakage of fluid in the form of a mist or fine spray may occur under normal operating conditions.~~

~~14.5.6~~ 14.2.4 The following ~~zones or spaces~~ areas are regarded as hazardous, **zone 0**:
(a) the interiors of those spaces, tanks, piping systems and equipment defined by ~~*Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(a)* and *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(b)*~~ *Pt 6, Ch 2, 14.1 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts 14.1.3(a)* and *Pt 6, Ch 2, 14.1 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts 14.1.3(b)*; and
(b) enclosed, unventilated spaces containing pipework or equipment defined by ~~*Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(b)* and *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(e)*~~ *Pt 6, Ch 2, 14.1 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts 14.1.3(b)* and *Pt 6, Ch 2, 14.1 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts 14.1.3(e)*.

~~14. 5.7~~ 14.2.5 The following ~~zones or spaces~~ areas are regarded as hazardous, **zone 1**:
(a) unventilated spaces separated by a single bulkhead or deck from a cargo defined by ~~*Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(b)*~~ *Pt 6, Ch 2, 14.1 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts 14.1.3(a)*;
(b) ventilated spaces containing pipework or equipment defined by ~~*Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(b)* and *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(e)*~~ *Pt 6, Ch 2, 14.1 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts 14.1.3(b)* and *t 6, Ch 2, 14.1 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts 14.1.3(e)*;
(c) zones within a ~~1,5~~ 3 m radius of ventilation outlets, hatches or doorways or other openings into spaces defined by *Pt 6, Ch 2, 14.2 Hazardous areas 14.2.5(a)* or *Pt 6, Ch 2, 14.2 Hazardous areas 14.2.5(b)*, ~~or within 1,5 m of the ventilation outlets of spaces regarded by 14.7 as open areas and which contain the pipework or equipment defined by 14.5.5(b) or (e)~~. ~~Where the hazard results from flammable gas or~~ vapour having a density relative to that of air of more than 0,75, the hazardous zone is considered to extend ~~vertically downward to solid deck, or for a distance of 9 m, whichever is the lesser~~;
(d) zones on open deck~~, or semi-enclosed spaces on open deck,~~ within 3 m of the ventilation outlets of cargo tanks defined in ~~*Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5*~~ *Pt 6, Ch 2, 14.1 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts 14.1.3(a)*, which permit the flow of small volumes of vapour or gas mixtures caused by thermal variation;
(e) zones within a ~~1,5~~ 3 m radius of flanged joints, or glands or other openings defined by ~~*Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(b)*~~ *Pt 6, Ch 2, 14.1 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts 14.1.3 (b)*; ~~in the case of gas or vapour having a relative density of more than 0,75, the hazardous zone is considered to extend vertically downwards as described under (c);~~
(f) zones within a 1,5 m radius of flanged joints, or glands or other openings defined by ~~*Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(e)* and *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5(f)*~~ *Pt 6, Ch 2, 14.1 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts 14.1.3(e)* and *Pt 6, Ch 2, 14.1 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts 14.1.3(f);*
(g) zones within a ~~1,5~~ 3 m radius of bunds or barriers intended to contain spillage of liquids defined by ~~*Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.5*~~ *Pt 6, Ch 2, 14.1 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts 14.1.3(a)*;
(h) zones on open deck within a 1,5 m radius of any opening into a space defined by *Pt 6, Ch 2, 14.2 Hazardous areas 14.2.5(a)*; ~~and~~
(i) enclosed or semi-enclosed spaces with direct opening into a **zone 1** hazardous location;
(k) zones within a 1,5 m radius of ventilation inlets or other openings serving spaces defined by (b); and
(l) zones on open deck within a vertical cylinder of unlimited height and 6 m radius centred upon the centre of the outlet, and within a hemisphere of 6 m radius below the outlet which permit the flow of large volumes of vapour or gas mixtures during loading/discharging/ballasting

14.~~5.8~~ 14.2.6 The following ~~zones or spaces~~ areas are regarded as hazardous, **zone 2**: and

(a) ventilated spaces separated by a single bulkhead or deck from a **zone 0** space;

(b) zones on open deck extending 1,5 m beyond those defined by ~~*Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(c)*, *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(e)*, *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(f)*, *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(g)* or *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(h)*~~ *Pt 6, Ch 2, 14.2 Hazardous areas 14.2.5(c), 14.2.5 (e), 14.2.5 (f), 14.2.5 (g)* or *14.2.5 (h)*;

(c) zones on open deck extending 2 m beyond those defined by ~~*Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(d)*~~ *Pt 6, Ch 2, 14.2 Hazardous areas 14.2.5 (d)*;

~~(d) zones within a 1,5 m radius of ventilation inlets serving spaces defined by *Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.7(b)*;~~

(d) zones on open deck extending 4m beyond those defined by *Pt 6, Ch 2, 14.2 Hazardous areas 14.2.5(i)*; and

(e) enclosed or semi-enclosed spaces with direct opening into a **zone 2** hazardous location.

14.2.7 Vertical and horizontal extent of hazardous zones defined by *Pt 6, Ch 2, 14.2 Hazardous areas 14.2.5* and *Pt 6, Ch 2, 14.2 Hazardous areas 14.2.6* is to be considered with reference to density relative to air of flammable gas or vapour encountered. *See* IEC 60079-10-1: *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres.*

14.2.8 Consideration may also be given to hazardous areas and sources of hazard defined in accordance with IEC 60079-10-1: *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres* and/or IEC 60079-10-2: *Explosive atmospheres — Part 10-2: Classification of areas – Combustible dust atmospheres.*

~~14.2~~ 14.3 Selection of equipment for use in explosive gas atmospheres

~~14.2.1~~ 14.3.1 When equipment is to be installed in areas where an explosive gas atmosphere may be present, it is ~~generally~~ to be of a type providing protection against ignition of the gases encountered and compliant with the relevant Parts of IEC 60079: *Explosive atmospheres*, or an acceptable and relevant National Standard, unless permitted otherwise by *Pt 6, Ch 2, 14.3 Selection of equipment for use in explosive gas atmospheres ~~14.2.4~~ 14.3.4*, *Pt 6, Ch 2, 14.3 Selection of equipment for use in explosive gas atmospheres ~~14.2.5~~ 14.2.3* or *Pt 6, Ch 2, 14.3 Selection of equipment for use in explosive gas atmospheres ~~14.2.6~~ 14.3.6*.

~~14.2.2~~ 14.3.2 The equipment protection type permitted depends on the hazardous ~~zone~~ area where the equipment is to be located, as defined in *Pt 6, Ch 2, ~~14.5~~ 14.2 Hazardous zones and spaces*. For certain locations on the ship other requirements may limit installations to specific equipment types and/or particular applications.

~~14.2.3~~ 14.3.3 Equipment for **zone 0** or **zone 1**, with the exception of simple apparatus as defined in *Pt 6, Ch 2, 14.3 Selection of equipment for use in explosive gas atmospheres ~~14.2.4~~ 14.3.4* or *Pt 6, Ch 2, 14.3 Selection of equipment for use in explosive gas atmospheres ~~14.2.5~~ 14.3.5*, is to be certified or approved by a National or other appropriate authority. Equipment without independent certification or approval may be considered for installation in **zone 2**.

~~14.2.4~~ 14.3.4 In **zone 0**, the following may be considered:

(a) intrinsically safe, category ‘a’ (Ex ‘ia’); or

(b) simple ~~electrical~~ apparatus ~~and components~~ (for example thermocouples, photocells, strain gauges, junction boxes, switching devices), included in intrinsically safe circuits of category ‘ia’, ~~not capable of storing or generating electrical power or energy in excess of the limits given in~~ compliant with IEC 60079-14: *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*.

~~14.2.5~~ 14.3.5 In **zone 1**, the following may be considered:

(a) ~~apparatus~~ equipment permitted within **zone 0**;

(b) intrinsically safe, category ‘b’ (Ex ‘ib’);

(c) simple apparatus as defined above, included in intrinsically safe circuits of category ‘ib’;

(d) increased safety (Ex ‘e’);

(e) flameproof (Ex ‘d’);

(f) pressurised enclosure (Ex ‘p’);

(g) powder filled (Ex ‘q’); or

(h) encapsulated (Ex ‘m’).

~~14.2.6~~ 14.3.6 In **zone 2**, the following may be considered:

(a) ~~apparatus~~ equipment permitted within **zone 0** or **zone 1**;

(b) type of protection ‘n’ or ‘N’;

(c) equipment such as control panels, protected by purging and pressurisation and capable of being verified by inspection as meeting the requirements of IEC 60079-2: *Explosive atmospheres – Part 2: Equipment protection by pressurized enclosures "p"*; or

(d) radio aerials having robust construction, meeting the relevant requirements of IEC 60079-15: *Explosive atmospheres – Part 15: Equipment protection by type of protection "n"*. Additionally, in the case of transmitter aerials, it is to be shown, by detailed study or measurement, or by limiting the peak radiated power and field strength to 1 W and 30 V/m, respectively, that they present negligible risk of inducing incendive sparking in adjacent structures or equipment.

~~14.2.7~~ 14.3.7 ~~Apparatus~~ Equipment having type of protection ‘ia’, ‘ib’, or ‘d’, is to be of a Group (IIA, IIB or IIC) meeting or exceeding that required for safe operation in the presence of any gas or vapour that can be present, or is to be certified specifically for such gases or vapours.

~~14.2.8~~ 14.3.8 All ~~apparatus~~ equipment is to be of a temperature classification (T1 to T6) that confirms, or is to be assessed so as to confirm, that its maximum surface temperature will not reach the ignition temperature of any gas or vapour, or mixture of gases or vapours, which can be present. The surface temperature considered may be that of an internal or external part, according to the type of protection of the ~~apparatus~~ equipment.

~~14.2.9~~ 14.3.9 Where optical fibre transmission equipment located in a hazardous or non-hazardous area provides energy to, or passes optical energy through, a hazardous area with an explosive gas atmosphere, then:
(a) The protection type to be appropriate to the zone classification, as detailed in *Table 2.14.1 Zone classification for types of protection associated with optical fibre transmission systems*.
(b) The optical energy levels in **zone 0** and **1**, including fault conditions, are to be limited to 5 mW/mm^2 or 35 mW for constant wave and 0,1 mJ/mm^2 pulsed.
(c) The optical energy levels in **zone 2**, including fault conditions, are to be limited to 10 mW/mm^2 or 35 mW for constant wave and 0,5 mJ/mm^2 pulsed, and
(d) Pulsed sources with a pulse interval less than 5 seconds, are to be considered constant wave sources.

~~14.2.10~~ 14.3.10 ~~Consideration may also be given to other types of protection, selected in accordance with the requirements of IEC 60079-14: *Explosive atmospheres – Part 14: Electrical installations design, selection and erection* or arrangements complying with IEC 60092-502: *Electrical installations in ships – Part 502: Tankers – Special features, see also Pt 6, Ch 2, 14.10 Requirements for tankers intended for the carriage in bulk of oil cargoes having a flash point not exceeding 60°C (closed-cup test)*to *Pt 6, Ch 2, 14.12 Requirements for ships intended for the carriage in bulk of other flammable liquid cargoes.*~~
Consideration may also be given to other types of protection, selected in accordance with the requirements of:
(a) IEC 60079-14: *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*, or
(b) Arrangements complying with IEC 60092-502: *Electrical installations in ships – Part 502: Tankers – Special features, see also Pt 6, Ch 2, 14.10 Requirements for tankers intended for the carriage of oil cargoes in bulk* to *Pt 6, Ch 2, 14.12 Requirements for ships intended for the carriage in bulk of other flammable liquid cargoes*.

Existing Table 2.14.1 Zone classification for types if protection associated with optical fibre transmission systems has been deleted in its entirety.

Table 2.14.1 Zone classification for types of protection associated with optical fibre transmission systems

Zone	Type of protection level	Associated requirements
0	'op is', Inherently safe optical radiation,	Safe with two faults
	'op sh', Protected fibre optic media with ignition capable beam interlocked with fibre breakage	additional mechanical protection required
1	'op is', Inherently safe optical, radiation	Safe with single fault
	'op pr', Protected fibre optic media with ignition capable beam	additional mechanical protection required
	'op sh', Protected fibre optic media with ignition capable beam interlocked with fibre breakage	additional mechanical protection not necessarily required
2	'op is', inherently safe optical radiation,	Safe in normal operation
	'op pr', Protected fibre optic media with ignition capable beam	additional mechanical protection not necessarily required
	'op sh', Protected fibre optic media with ignition capable beam interlocked with fibre breakage	additional mechanical protection not necessarily required

~~14.3~~ 14.4 Selection of equipment for use in the presence of combustible dusts

~~14.3.1~~ 14.4.1 Where ~~apparatus~~ equipment is to be installed in **hazardous areas**, as defined by *Pt 6, Ch 2, 14.2 Hazardous areas* ~~*14.5.3*~~ *14.2.3*, associated with the presence of combustible dusts, it is~~, when practicable,~~ to be of a type certified ~~or approved~~ by a National or other appropriate authority for the combustible dusts and, additionally, any explosive gases encountered.

14.4.2 Where optical fibre transmission equipment located in a **hazardous area**, **extended hazardous area** or non-hazardous area provides energy to, or passes optical energy through, a hazardous area with combustible dusts, then the optical energy levels are to be:
(a) restricted in **hazardous area** to 5 mW/mm^2 or 35 mW maximum for constant wave sources or 0,1 mJ/mm^2 for pulsed sources;
(b) restricted in **extended hazardous area** to 10 mW/mm^2 or 35 mW maximum, for constant wave sources or 0,5 mJ/mm^2 for pulsed sources;
(c) where a pulsed source has a pulse interval less than 5 seconds, it is to be considered constant wave source.

~~14.3.3~~ 14.4.3 Electrical equipment for use in ~~such~~ **hazardous areas** is to be ~~so~~ designed and installed ~~as~~ to minimise the accumulation of dust which may interfere with the safe dissipation of heat from the enclosure.

~~14.3.4~~ 14.4.4 Where ~~apparatus~~ equipment is to be installed in **extended hazardous areas**, as defined by *Pt 6, Ch 2, 14.2 Hazardous areas* ~~*14.5.3*~~ *14.2.3*, associated with the presence of combustible dust and, additionally, any explosive gases encountered, the following may be considered:
(a) ~~apparatus~~ equipment permitted within a ~~hazardous area~~ **hazardous area** ~~associated with the combustible dust(s) that can be present~~ as defined by *Pt 6, Ch 2, 14.4 Selection of equipment for use in presence of combustible dusts 14.4.1*;

(b) ~~apparatus~~ equipment having degree of protection IP5X, or better, and having a surface temperature ~~under normal operating conditions not exceeding the auto-ignition temperature of the dust(s) that can be present;~~ under normal operating conditions, but in the absence of a combustible dust layer, not exceeding two-thirds of the minimum ignition temperature in degrees Celsius of the combustible dust/air mixture(s) that can be present and appropriate for any explosive gases encountered;and
(c) ~~apparatus~~ equipment of a type which ensures absence of sparks or arcs and hot spots during normal operation.

~~14.3.5~~ 14.4.5 Where equipment certified for combustible dusts is not available, consideration will be given to the use of ~~apparatus~~ equipment complying as a minimum, with the following requirements provided no explosive gases will be present:
(a) the enclosure is to be at least dust protected (IP5X) having, when ~~type~~ tested in accordance with IEC 60529, an ingress of fine dust within the enclosure not exceeding 10 g per m^3 of free air space, and
(b) the surface temperature of the ~~apparatus~~ equipment, under ~~the most onerous combination of~~ normal operating conditions, but in the absence of a combustible dust layer, is not to exceed two-thirds of the minimum ignition temperature in degrees Celsius of the combustible dust/air mixture(s) that can be present, or
(c) the equipment is to be certified intrinsically safe “ia” or “ib” having a temperature classification ensuring compliance with *Pt 6, Ch 2, 14.4 Selection of equipment for use in the presence of combustible dusts 14.4.5(b)*, or
(d) pressurised and operated in accordance with procedures ensuring, prior to its re-energisation, the absence of combustible dust within the enclosure following loss of pressurisation and consequent shut-down, and having surface temperature complying with (b), or
(e) simple apparatus included in intrinsically safe circuits or radio aerials, complying with *Pt 6, Ch 2, 14.3 Selection of equipment for use in explosive gas atmospheres ~~14.2.5~~ 14.3.5* or *Pt 6, Ch 2, 14.3 Selection of equipment for use in explosive gas atmospheres ~~14.2.6~~ 14.3.6* respectively.

~~14.3.6~~ 14.4.6 Consideration may also be given to other types of protection, selected in accordance with the requirements of:
(a) IEC 60079-14: *Explosive atmospehres – Part 14: Electrical installations design, selection and erection, or*
(b) arrangements complying with IEC 60092-506: *Electrical Installation in ships – Part 506: Special features – Ships carrying specific dangerous goods and materials hazardous only in bulk*.

~~14.4 Installation of electrical equipment~~

~~14.4.1 The method of installation and application of electrical equipment suitable for use in explosive gas atmospheres or in the presence of combustible dusts is to be in accordance with IEC 60079-14:~~ ~~*Explosive atmospheres – Part 14: Electrical installations design, selection and erection*~~~~, or the national code of practice relevant to the standard with which the equipment complies. The ambient temperature range for which the apparatus is certified is to be taken to be –20°C to 40°C, unless otherwise stated, and account is to be taken of this when assessing the suitability of the equipment for the auto-ignition temperature of the gases and dusts encountered. Any special requirements laid down by the equipment certification documentation are also to be observed.~~

~~14.4.2 All switches and protective devices from which equipment located in hazardous zones or spaces is supplied are to interrupt all poles or phases and, where practicable are to be located in a non-hazardous zone or space. Such equipment, switches and protective devices are to be suitably labelled for identification purposes.~~

14.5 Installation of electrical equipment

14.5.1 The method of installation and application of electrical equipment suitable for use in explosive gas atmospheres or in the presence of combustible dusts is to be in accordance with:
(a) IEC 60079-14: *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*; or
(b) the National code of practice relevant to the standard with which the equipment complies.

14.5.2 The ambient temperature range for which the equipment is certified is to be taken to be –20°C to 40°C, unless otherwise stated, and account is to be taken of this when assessing the suitability of the equipment for the auto-ignition temperature of the gases and combustible dusts encountered.

14.5.3 Any special requirements laid down by the equipment certification documentation are also to be observed.

14.5.4 All switches and protective devices from which electrical equipment located in hazardous areas is supplied are to be located in non-hazardous areas. Where it is not practicable to locate the switches and protective devices in non-hazardous area, then the applicable requirements of this section are to be applied to that equipment.

14.5.5 All switches and protective devices from which electrical equipment located in hazardous areas is supplied are to interrupt all poles or phases.

14.5.6 Electrical equipment in hazardous areas, switches and protective devices are to be clearly labelled for identification purposes.

14.6 Semi-enclosed spaces

14.6.1 Semi-enclosed spaces are considered to be spaces limited by decks and/or bulkheads in such a manner that the natural conditions of ventilation are ~~sensibly~~ different from those obtained on open deck.

14.7 Ventilation

14.7.1 ~~Where an enclosed or semi-enclosed space is provided with mechanical ventilation ensuring at least 12 air changes/hour, and leaving no areas of stagnant air, it may be regarded in consideration of hazardous zones as would otherwise be defined by 14.5.6(b), 14.5.7(b) or (h) and 14.5.8(d), as an open area~~ Natural or mechanical ventilation is to be provided for hazardous enclosed or semi-enclosed areas in order to prevent accumulation of explosive gas atmosphere, leaving no areas of stagnant air. Ventilation rates are to be calculated based on IEC 60079-10-1: *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*.

14.8 Pressurisation

14.8.1 A space having access to a hazardous ~~space or zone~~ area defined as **zone 1** or **zone 2** may be regarded as non-hazardous if ~~fulfilling all the following conditions~~ all following requirements are met:

(a) access is by means of an air-lock, having gastight steel doors, the inner of which as a minimum, is self-closing without any hold-back arrangement;
(b) it is maintained at an overpressure (minimum 0,25 mbar) relative to the external hazardous area by ventilation from a non-hazardous area;
~~(c) the relative air pressure within the space is continuously monitored and so arranged that, in the event of loss of overpressure, an alarm is given and the electrical supply to all equipment not of a type suitable for **zone 1** is automatically disconnected. Where the shutdown of equipment could introduce a hazard, an alarm may be given, in lieu of shutdown, upon loss of overpressure, and a means of disconnection of electrical equipment not of a type suitable for **zone 1**, capable of being controlled from an attended station, provided in conjunction with an agreed operational procedure; where the means of disconnection is located within the space then it is to be effected by equipment of a type suitable for **zone 1**;~~
(c) the relative air pressure within the space is continuously monitored and so arranged that:
  (i) in the event of loss of overpressure, an alarm is given;
  (ii) the electrical supply to all equipment not of a type suitable for **zone 1** is automatically disconnected;
  (iii) where the disconnection of equipment could introduce a hazard, an alarm may be given, in lieu of automatic disconnection, upon loss of overpressure; and
  (iv) a means of manual disconnection of electrical equipment not of a type suitable for **zone 1**, capable of being controlled from an attended station, is to be provided in conjunction with an agreed operational procedure; and
  (v) where the means of disconnection, capable of being controlled from an attended station, is located within the space then it is to be of a type suitable for **zone 1**;
(d) any electrical equipment required to operate upon loss of overpressure, lighting fittings (*see* 5.7.3) and equipment within the air-lock, is to be of a type suitable for **zone 1**; and
(e) means are to be provided to prevent electrical equipment, other than of a type suitable for **zone 1**, being energised until the atmosphere within the space is made safe, by air changes ~~renewal~~ of at least 10 times the capacity of the space.

14.8.2 A space having access to a hazardous ~~space or zone~~ area defined as **zone 2** may be regarded as non-hazardous if ~~fulfilling all the following conditions~~ all following requirements are met:

(a) access is by means of a self-closing gastight steel door without any hold-back arrangement;
(b) it is maintained at an overpressure (minimum 0,25 mbar) relative to the external hazardous area by ventilation from a non-hazardous area;
~~(c) the relative air pressure within the space is continuously monitored and so arranged that, in the event of loss of overpressure, an alarm is given. A means of disconnection of electrical equipment not of a type suitable for **zone 2** is to be provided; where the means of disconnection is located within the space then it is to be effected by equipment of a type suitable for **zone 2**;~~
(c) the relative air pressure within the space is continuously monitored and so arranged that:
  (i) in the event of loss of overpressure, an alarm is given; and
  (ii) a means of manual disconnection of electrical equipment not of a type suitable for **zone 2,** capable of being controlled from an attended station, is to be provided; where the means of disconnection, capable of being controlled from an attended station, is located within the space then it is to be of a type suitable for **zone 2**;
(d) any electrical equipment required to operate upon loss of overpressure (e.g.~~,~~ lighting fittings, *see Pt 6, Ch 2, 5.7 Lighting circuits 5.7.3*), is to be of a type suitable for **zone 2**; and
(e) means are to be provided to prevent electrical equipment, other than of a type suitable for **zone 2**, being energised until the atmosphere within the space is made safe, by air changes of at least 10 times the capacity of the space.

14.9 Cable and cable installation

14.9.1 Electric cables are not, as far as is practicable, to be installed in hazardous ~~zones or spaces~~ areas, except where serving equipment installed within the ~~zone or space~~ area. Through runs of cable may be accepted in locations classified as **zone 1** or **zone 2**, where alternative routes are impracticable.

14.9.2 In addition to the requirements of *Pt 6, Ch 2, 11 Electric cables, optical fibre cables and busbar trunking systems (busways)*, cables for circuits that are not intrinsically safe, which are located in hazardous ~~zones or spaces~~ areas, or which may be exposed to cargo oil, oil vapour or gas, are to be either:

~~(a) mineral insulated with copper sheath, or~~
(~~b~~)(a) armoured or braided for earth detection, or
(~~c~~)(b) otherwise adequately protected against mechanical or chemical damage, within **zone 2** or non-hazardous areas ~~locations~~ only, or
(~~d~~)(c) as otherwise specifically permitted elsewhere within this Section, or
(d) mineral insulated with copper sheath.

14.9.3 Armouring, braiding and other metal coverings of cables installed in ~~dangerous zones or spaces~~ hazardous areas are to be effectively earthed at least at both ends.

14.9.5 Cables associated with intrinsically safe circuits are to be used only for such circuits. They are to be physically separated from cables associated with non-intrinsically safe circuits, e.g.~~,~~ neither installed in the same protective casing nor secured by the same fixing clip. Consideration may be given to other arrangements complying with IEC 60079-14, *Explosive atmospheres — Part 14: Electrical installations design, selection and erection*.

14.9.7 Cable runs in **zone 1** or **zone 2** are, where practicable, to be uninterrupted. Where discontinuities cannot be avoided, cable joints are~~, additionally,~~ to:

- be made in an enclosure with a type of protection appropriate to the location; or
- provided the joint is not subject to mechanical stress, be epoxy filled, compound-filled or sleeved with heat-shrunk tubing, in accordance with the manufacturer's instructions.

14.10 Requirements for tankers intended for the carriage of oil cargoes in bulk ~~having a flash point not exceeding 60°C (closed-cup test)~~

14.10.1 ~~In order to eliminate potential sources of ignition from hazardous areas on board tankers in accordance with *SOLAS - International Convention for the Safety of Life at Sea* as amended, Chapter II-1, *Regulation 45 - Precautions against shock, fire and other hazards of electrical origin (Paragraphs 10 and 11 of this regulation apply to ships constructed on or after 1 January 2007)*, electrical equipment is to be selected and installed in accordance with IEC 60092: *Electrical installations in ships – Part 502: Tankers – Special features*.~~ *See* IEC 60092: *Electrical installations in ships – Part 502: Tankers – Special features*.

~~14.10.2 The relevant group and temperature class for electrical equipment in hazardous zones are, respectively, IIA and T3.~~

14.12 Requirements for ships intended for the carriage ~~in bulk~~ of other flammable liquid cargoes in bulk

14.12.1 *See Chapter 10 Electrical Installations* of the Rules for Ships for Liquid Chemicals.

14.13 Special requirements for ships with spaces for carrying vehicles with fuel in their tanks, for their own propulsion

~~14.13.1~~ 14.13.1 **Passenger ships with special category spaces below the bulkhead deck for carrying vehicles**: electrical equipment fitted within the space and within the exhaust ventilation trunking for the space, is to be of a type acceptable for **zone 1**.

~~14.13.1~~ 14.13.2 **Passenger ships with special category spaces above the bulkhead deck for carrying vehicles**:

(a) electrical equipment fitted within a height of 45 cm above the vehicle deck, or any platform on which vehicles are carried, or within the exhaust ventilation trunking for the space, is to be of a type acceptable for **zone 1**;

(b) electrical equipment situated elsewhere within the space is to be of a type acceptable for **zone 2**, or is to have an enclosure of ingress protection rating of at least IP55, *see* IEC 60529: *Degrees of protection provided by enclosures (IP Code)*.

~~14.13.3 **Passenger ships with cargo spaces, other than special category spaces, for carrying vehicles:**~~

~~(a) electrical equipment within such a cargo space, or within the exhaust ventilation trunking for the space, is to be of a type acceptable for **zone 1**;~~

~~(b) all electrical circuits terminating in the cargo space are to be provided with multipole linked isolating switches located outside the cargo hold. Provision is to be made for locking in the off position. This does not apply to safety circuits such as those for fire, smoke or gas detection.~~

~~14.13.4 **Cargo ships with closed ro-ro cargo spaces for carrying vehicles**:~~

~~(a) except where exempted by (b) electrical equipment fitted within the space and within the exhaust ventilation trunking for the space is to be of a type acceptable for **zone 1**;~~

~~(b) where the ventilation system required by *SOLAS - International Convention for the Safety of Life at Sea as amended, Chapter II-2, Regulation 20 - Protection of vehicle, special category and ro-ro spaces, 20.3.1.1* is arranged to operate continuously and is sufficient to provide at least ten air changes per hour, whenever vehicles are on board, above a height of 45 cm from the vehicle deck, or any platform on which vehicles are carried, electrical equipment is to be of a type acceptable for **zone 2**, or is to have an enclosure of ingress protection rating of at least IP 55;~~

~~(c) all electrical circuits terminating in the cargo space are to be provided with multipole linked isolating switches located outside the cargo hold. Provision is to be made for locking in the off position. This does not apply to safety circuits such as those for fire, smoke or gas detection.~~

14.13.3 **Passenger ships with cargo spaces, other than special category spaces, for carrying vehicles and cargo ships with closed ro-ro cargo spaces for carrying vehicles**:

(a) except where exempted by (b) electrical equipment fitted within the space and within the exhaust ventilation trunking for the space is to be of a type acceptable for **zone 1**;

(b) where the ventilation system required by *SOLAS - International Convention for the Safety of Life at Sea as amended, Chapter II-2, Regulation 20 - Protection of vehicle, special category and ro-ro spaces, 20.3.1.1* is arranged to operate continuously and is sufficient to provide at least ten air changes per hour, whenever vehicles are on board, electrical equipment above a height of 45 cm from the vehicle deck, or any platform on which vehicles are carried, is to be of a type acceptable for **zone 2**, or is to have an enclosure of ingress protection rating of at least IP 55.

~~14.13.5~~ 14.13.4 **Vehicle carriers with spaces for carrying vehicles with compressed natural gas in their tanks, for their own propulsion:**

- electrical equipment fitted within the space and within any ventilation trunking for the space, is to be of a type acceptable for **zone 1**. *See also* ~~*Pt 6, Ch 2, 14.2 Selection of equipment for use in explosive gas atmospheres 14.2.7*~~ *Pt 6, Ch 2, 14.3 Selection of equipment for use in explosive gas atmosphere 14.3.7*.

~~14.13.6~~ 14.13.5 **Vehicle carriers with spaces for carrying vehicles with compressed hydrogen in their tanks, for their own propulsion**:

- electrical equipment fitted within the space and within any ventilation trunking for the space, is to be of a type acceptable for zone 1. See also Sec.~~ *Pt 6, Ch 2, 14.2 Selection of equipment for use in explosive gas atmospheres 14.2.7*~~ *Pt 6, Ch 2, 14.3 Selection of equipment for use in explosive gas atmosphere 14.3.7*.

14.14 Special requirements for ships intended for the carriage of dangerous goods and materials hazardous only in bulk

~~14.14.1 In order to eliminate potential sources of ignition in enclosed cargo spaces or vehicle spaces in accordance with *SOLAS - International Convention for the Safety of Life at Sea* as amended, Chapter II-2, *Regulation 19 - Carriage of dangerous goods1*, and from associated hazardous areas (*see Pt 6, Ch 2, 14.5 Hazardous zones and spaces 14.5.3*), electrical equipment is to be selected in accordance with *Pt 6, Ch 2, 14.14 Special requirements for ships intended for the carriage of dangerous goods and materials hazardous only in bulk 14.14.2* and *Pt 6, Ch 2, 14.14 Special requirements for ships intended for the carriage of dangerous goods and materials hazardous only in bulk 14.14.3* and installed in accordance with *Pt 6, Ch 2, 14.4 Installation of electrical equipment* and *Pt 6, Ch 2, 14.14 Special requirements for ships intended for the carriage of dangerous goods and materials hazardous only in bulk 14.14.4* to *Pt 6, Ch 2, 14.14 Special requirements for ships intended for the carriage of dangerous goods and materials hazardous only in bulk 14.14.6*.~~

~~14.14.2~~ 14.14.1 Electrical equipment essential for the safety and operation of the ship is to be of a type providing protection against ignition of the gases and/or combustible dusts that can be present, selected in accordance with IEC 60092-506: *Electrical installations in ships – Part 506: Special features – Ships carrying specific dangerous goods and materials hazardous only in bulk*.

~~14.14.3~~ 14.14.2 In addition to the requirements of IEC 60092-506: *Electrical installations in ships – Part 506: Special features – Ships carrying specific dangerous goods and materials hazardous only in bulk*, pipes such as ventilation and bilge pipes having ends opening into a ~~hazardous area~~ **hazardous area** are to be considered a ~~hazardous area~~ **hazardous area**. Enclosed spaces such as pipe tunnels and bilge pump-rooms containing such pipes and with equipment and components such as pumps, valves and flanges are to be considered as ~~extended hazardous area~~ **extended hazardous areas** unless protected by overpressure.

~~14.14.4~~ 14.14.3 Electrical equipment not essential for the safety or operation of the ship and which is not of a type providing protection against ignition of the gases and/or combustible dusts that can be present is to be completely disconnected and protected against unauthorised re-connection. Disconnection is to be made outside the hazardous areas and be effected with isolating links or lockable switches.

~~14.14.5~~ 14.14.4 Electrical equipment and all cables, including through runs and terminating cables, are to be protected against mechanical damage. Cables are to be either enclosed in screwed heavy gauge steel drawn or seam-welded and galvanised conduit, or protected by electrically continuous metal sheathing or metallic wire armour braid or tape.

~~14.14.6~~ 14.14.5 Cable penetrations of decks and bulkheads are to be sealed against the passage of gas or vapour.

14.15 Requirements for ships with spaces for storing paint

14.15.1 In order to eliminate potential sources of ignition in paint stores, electrical equipment is to be selected as follows:

(a) electrical equipment fitted within the space and within the ~~exhaust~~ ventilation trunking for the space is to be of a type acceptable for **zone 1**;

(b) electrical equipment situated within 1 m of inlet and exhaust ventilation openings or within 3 m of exhaust mechanical ventilation outlets is to be of a type acceptable for **zone 2**, or is to have an enclosure of ingress protection rating of at least IP55 and maximum surface temperature equivalent to temperature class T3, *see* IEC 60529, *Classification of Degrees of Protection Provided by Enclosures*. *See* 1.11.1 for degrees of protection required for equipment on open deck.

■ *Section 15*

Navigation and manoeuvring systems

15.1 Steering gear

15.1.1 The requirements of *Pt 6, Ch 2, 15.1 Steering gear 15.1.2* to *Pt 6, Ch 2, 15.1 Steering gear 15.1.5* are to be read in conjunction with those in *Pt 5, Ch 19, 4 Steering control systems* and *Pt 5, Ch 19, 5 Electric power circuits, electric control circuits, monitoring and alarms*.

■ *Section 16*
Electric propulsion

16.5 Harmonic filtering for propulsion

16.5.1 The requirements in this ~~section~~ Section apply to systems provided with harmonic filters and are in addition to the requirements for harmonic filters in *Pt 6, Ch 2, 5.11 Harmonic filtering* and *Pt 6, Ch 2, 6.13 Harmonic filters.*

~~16.5.2 Line filters used to control harmonic distortion are to keep the distortion within acceptable limits at the main supply.~~

~~16.5.3~~ 16.5.2 In the event of filter circuit failure, continued safe operation of the propulsion system is to be possible by following appropriate procedures, as specified by the manufacturer and/or system integrator. These procedures are to include any operational limitations, and they are to be kept on-board and made available to the Surveyor on request.

~~16.5.4 The service life of the harmonic filter is to be declared, and details are to be made available to the Surveyor on request.~~

~~16.5.5 Where parallel filter circuits are to be used the current imbalance is to be monitored;~~

~~16.5.6 The temperature rating of the harmonic filter is to allow for the increased heating effect of the harmonic distortion, and to be tested during sea trials~~

~~16.5.7 The construction of cabinets for harmonic filters shall be in accordance with the standards for main switchboards, where applicable. *See also Pt 6, Ch 2, 7 Switchgear and controlgear assemblies*.~~

■ *Section 21*
Testing and trials

21.2 Trials

(*Part only shown*)

21.2.4 It is to be demonstrated that the Rules have been complied with in respect of:

(f) harmonic distortion of the voltage waveform~~, where declared;~~. Where harmonic filters are installed the calculation results provided by the system integrator are to be verified by the Surveyor. Simulation on trials of harmonic filter failure that would result in THD levels calculated to be higher than the acceptable limit are to be avoided. *See Pt 6, Ch 2, 5.11 Harmonic filtering;*

(j) the operation of the propulsion system with the harmonic filter removed from circuit is to be verified in accordance with the design intent, *see Pt 6, Ch 2, 16.5 Harmonic filtering for propulsion 16.5.3*; any operational and functional limitations are to be documented and details retained on board; and

Part 7, Chapter 5
Ships Equipped for Oil Recovery Operations

■ *Section 5*
Electrical equipment

5.1 General

5.1.1 The electrical installation is to comply with the relevant requirements of *Pt 6, Ch 2 Electrical Engineering*, with the specific exceptions of *Pt 6, Ch 2, 14.1 General*, *Pt 6, Ch 2, 14.3 Selection of equipment for use in explosive gas atmospheres*, ~~*Pt 6, Ch 2, 14.5 Hazardous zones and spaces*~~ *Pt 6, Ch 2, 14.3 Selection of equipment for use in explosive gas atmospheres*, *Pt 6, Ch 2, 14.7 Ventilation*, *Pt 6, Ch 2, 14.8 Pressurisation* and *Pt 6, Ch 2, 14.10 Requirements for tankers intended for the carriage of oil cargoes in bulk*, which are replaced by *Pt 7, Ch 5, 5.3 Hazardous zones and areas* to *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas* of this Chapter.

5.3 Hazardous ~~zones and spaces~~ areas

~~5.3.1 The following zones or spaces are regarded as hazardous during and on completion of oil recovery operations, until proven gas-safe:~~

~~(a) The interiors of tanks intended for the storage of recovered oil.~~
~~(b) The interiors of piping systems intended for the handling of recovered oil.~~
~~(c) Spaces separated by a single bulkhead, deck or other tank boundary, from the interior of a tank intended for recovered oil, or having a bulkhead immediately above or below and in line with a bulkhead of a tank intended for recovered oil, unless protected by a diagonal plate in accordance with *Pt 4, Ch 9, 1.2 Application and ship arrangement 1.2.7* or the arrangements comply with the requirements of *Pt 7, Ch 5, 3.1 Structural arrangement 3.1.7*.~~
~~(d) Spaces housing piping systems or other equipment containing or contaminated with recovered oil and having flanged joints or glands or other openings from which leakage of fluid may occur under normal operating conditions.~~
~~(e) Zones on open deck within a 3 m radius of the ventilation outlets, or inspection hatches permitted to be opened under normal operating conditions, of tanks intended for recovered oil.~~
~~(f) Zones on open deck within a 1,5 m radius of any sampling or sounding point of a tank intended for recovered oil.~~
~~(g) Zones on open deck within a 1,5 m radius of any flanged joints, glands or other parts of any equipment containing or contaminated with recovered oil from which leakage may occur under normal operating conditions.~~
~~(h) Zones on open deck within the confines of, and extending 1,5 m beyond, any bund or barrier intended to contain a spillage of recovered oil, up to a height of 1,5 m.~~
~~(i) Zones on open deck within a 1,5 m radius of any opening into a space described by *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(c)* or *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1 (d)*.~~
~~(j) Zones on open deck over all tanks intended for recovered oil, where the tops of the tanks are exposed to the weather, to the full width of the ship plus 3 m fore and aft of the forwardmost and aftmost tank bulkhead, up to a height of 0,45 m above the deck or to the height of any bulwarks.~~
~~(k) Zones on open deck extending 1,5 m beyond those defined by *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(e)* to *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(j)*.~~
~~(l) Any enclosed or semi-enclosed space having a direct opening into a hazardous zone or space identified above, unless the space is protected by pressurisation in accordance with *Pt 7, Ch 5, 5.5 Pressurisation 5.5.1* or *Pt 7, Ch 5, 5.5 Pressurisation 5.5.2*, or the opening is a ventilation outlet arranged in compliance with *Pt 7, Ch 5, 5.5 Pressurisation 5.4.2*.~~

5.3.1 Hazardous areas associated with oil recovery operations are classified into zones based upon the frequency of the occurrence and duration of an explosive gas atmosphere, as follows:

- **zone 0**: an area in which an explosive atmosphere is present continuously or for long periods or frequently
- **zone 1**: an area in which an explosive atmosphere is likely to occur periodically or occasionally in normal operation
- **zone 2**: an area in which an explosive atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

See IEC 60079-10-1: *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*.

5.3.2 The following areas are regarded as hazardous, **zone 0**:

(a) The interiors of tanks intended for the storage of recovered oil.
(b) The interiors of piping systems intended for the handling of recovered oil.
(c) The interiors of equipment containing or contaminated with recovered oil.
(d) Unventilated spaces housing piping systems or other equipment containing or contaminated with recovered oil and having flanged joints or glands or other openings from which leakage of fluid may occur under normal operating conditions.

5.3.3 The following areas are regarded as hazardous, **zone 1**:

(a) Unventilated spaces:
    (i) separated by a single bulkhead, deck or other tank boundary from the interior of a tank intended for recovered oil, or
    (ii) having a bulkhead immediately above or below and in line with a bulkhead of a tank intended for recovered oil, unless protected by a diagonal plate in accordance with *Pt 4, Ch 9, 1.2 Application and ship arrangement 1.2.9* or the arrangements comply with the requirements of *Pt 7, Ch 5, 3.1 Structural arrangement 3.1.7*.

(b) Ventilated spaces housing piping systems or other equipment containing or contaminated with recovered oil and having flanged joints or glands or other openings from which leakage of fluid may occur under normal operating conditions.
(c) Areas on open deck within a 3 m radius of:
  (i) ventilation outlets of tanks intended for recovered oil; or
  (ii) inspection hatches permitted to be opened under normal operating conditions of tanks intended for recovered oil; or
  (iii) any sampling or sounding points of tanks intended for recovered oil; or
  (iv) any flanged joints, glands or other parts of any equipment containing or contaminated with recovered oil from which leakage may occur under normal operating conditions; or
  (v) ventilation outlets from spaces described by *Pt 7, Ch 5, 5.3 Hazardous areas 5.3.3(a)* or *Pt 7, Ch 5, 5.3 Hazardous areas 5.3.3 (b)*.
(d) Areas on open deck within the confines of, and extending 3 m beyond, any bund or barrier intended to contain a spillage of recovered oil, up to a height of 2,4 m.
(e) Areas on open deck within a 1,5 m radius of any opening into a space described by *Pt 7, Ch 5, 5.3 Hazardous areas 5.3.3 (a)* or *Pt 7, Ch 5, 5.3 Hazardous areas 5.3.3 (b)*.
(f) Enclosed or semi-enclosed spaces with direct opening into a **zone 1** hazardous area.

5.3.4 The following areas are regarded as hazardous, **zone 2**:
(a) Ventilated spaces as defined by *Pt 7, Ch 5, 5.3 Hazardous areas 5.3.3 (a)*.
(b) Areas on open deck extending 1,5 m beyond those defined by *Pt 7, Ch 5, 5.3 Hazardous areas 5.3.3 (c)* to *5.3.3 (f)*.
(c) Areas on open deck with unrestricted natural ventilation over all tanks intended for recovered oil, where the tops of the tanks are exposed to the weather, to the full width of the ship plus 3 m fore and aft of the forward-most and aft-most tank bulkhead, up to a height of 0,45 m above the deck or to the height of any bulwarks.
(d) Enclosed or semi-enclosed spaces with direct opening into a **zone 2** hazardous area.

5.3.5 Vertical and horizontal extent of hazardous areas defined by *Pt 7, Ch 5, 5.3 Hazardous areas 5.3.3* and *Pt 7, Ch 5, 5.3 Hazardous areas 5.3.4* is to be additionally considered with reference to density relative to air of flammable gas or vapour encountered. *See* IEC 60079-10-1: *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres.*

5.3.6 Consideration may also be given to hazardous areas and sources of hazard defined in accordance with IEC 60079*: 10-1: Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres* and the following are to be submitted.
(a) Design statement that defines the service profile of the oil recovery ship;
(b) A concept of operation (ConOps) document, which is to include:
  (i) a functional description of how the ship is intended to be operated; and
  (ii) details of the ship's intended service, including the overall purpose(s), and the maximum duration of oil recovery operations per year;
(c) Hazardous area classification data sheets, as required by IEC 60079-10-1: *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*;
(d) Hazardous area plans, indicating the location of hazardous areas, and their openings, access and ventilation arrangements;
(e) The hazardous areas classification study is to consider the operation of the oil recovery equipment in reasonably foreseeable normal and abnormal operations; and
(f) Schedule of electrical and mechanical equipment to be located in hazardous areas.

5.4 Ventilation

5.4.1 The extent of any hazardous ~~zone~~ area within an enclosed or semi-enclosed space may be limited to that defined for an equivalent situation on open deck, provided that the ventilation arrangements fulfil all the following conditions:
(a) Mechanical ventilation is provided, with the air intake and outlet located outside any hazardous area defined by *Pt 7, Ch 5, 5.3 Hazardous areas 5.3.1*, ensuring at least 12 air changes per hour, and leaving no region of stagnant air.
(b) Ventilation air flow is continuously monitored and so arranged that, in the event of failure of ventilation, an alarm is given at an attended station.

5.4.2 An enclosed or semi-enclosed space having a ventilation outlet situated in a hazardous ~~zone~~ area, as defined under *Pt 7, Ch 5, 5.3 Hazardous areas 5.3.4(b)* or *Pt 7, Ch 5, 5.3 Hazardous areas 5.3.4(c)*, may be regarded as non-hazardous if fulfilling all the following conditions:
(a) The space has mechanical ventilation with the air intake ~~located outside any hazardous area defined by *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1*~~ from a non-hazardous area.
(b) The ventilation outlet is equipped with a self-closing flap or other suitable means of closure operating automatically on loss of ventilation airflow.
(c) The space contains no equipment of a type described in *Pt 7, Ch 5, 5.3 Hazardous areas* ~~*5.3.1*~~ *5.3.2*, or vent from or opening into any hazardous area defined by *Pt 7, Ch 5, 5.3 Hazardous areas 5.3.1*, other than the ventilation outlet under consideration.
(d) The space is separated by at least two gastight bulkheads from the interior of any tank intended for recovered oil.

5.5 Pressurisation

~~5.5.1 A space having access to a hazardous space or zone, as defined under *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(c)* to *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(j)*, may be regarded as non-hazardous if it fulfils all of the following conditions:~~
~~(a) Access is by means of an air-lock, having gastight doors, the inner of which, as a minimum, is self-closing without any hold-back arrangement.~~
~~(b) It is maintained at an overpressure of at least 50 Pa relative to the external hazardous area by ventilation from a non-hazardous area.~~

~~(c)~~ ~~The relative air pressure within the space is continuously monitored and so arranged that, in the event of loss of overpressure, an alarm is given at an attended station.~~

~~(d)~~ ~~It contains no piping system or equipment of a type described in *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(d)*, and no vent from or opening into any hazardous space or zone defined by *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1*, other than the access under consideration.~~

~~(e)~~ ~~It is separated by at least two gastight bulkheads from the interior of any tank intended for recovered oil.~~

5.5.1 A space having access to a hazardous area defined as **zone 1** may be regarded as non-hazardous if all following requirements are met:

(a) access is by means of an air-lock, having gastight steel doors, the inner of which, as a minimum, is self-closing without any hold-back arrangement;

(b) it is maintained at an overpressure (minimum 0,25 mbar) relative to the external hazardous area by ventilation from a non-hazardous area;

(c) the relative air pressure within the space is continuously monitored and so arranged that:

  (i) in the event of loss of overpressure, an alarm is given;

  (ii) the electrical supply to all equipment not of a type suitable for **zone 1** is automatically disconnected;

  (iii) where the disconnection of equipment could introduce a hazard, an alarm may be given, in lieu of automatic disconnection, upon loss of overpressure; and

  (iv) a means of manual disconnection of electrical equipment not of a type suitable for **zone 1**, capable of being controlled from an attended station, is to be provided in conjunction with an agreed operational procedure; and

  (v) where the means of disconnection, capable of being controlled from an attended station, is located within the space then it is to be of a type suitable for **zone 1**;

(d) any electrical equipment required to operate upon loss of overpressure, lighting fittings and equipment within the air-lock, is to be of a type suitable for **zone 1**;

(e) means are to be provided to prevent electrical equipment, other than of a type suitable for **zone 1**, being energised until the atmosphere within the space is made safe, by air changes of at least 10 times the capacity of the space; and

(f) it is separated by at least two gastight bulkheads from the interior of any tank intended for recovered oil.

~~5.5.2 A space having access to a hazardous zone, as defined under *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(k)* or *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(l)*, may be regarded as non-hazardous if it fulfils all of the following conditions:~~

~~(a)~~ ~~Access is by means of a gastight self-closing door without any hold back arrangement.~~

~~(b)~~ ~~It is maintained at an overpressure in accordance with *Pt 7, Ch 5, 5.5 Pressurisation 5.5.1(b)*.~~

~~(c)~~ ~~The air pressure within the space is monitored in accordance with *Pt 7, Ch 5, 5.5 Pressurisation 5.5.1(c)*.~~

~~(d)~~ ~~It contains no piping system or equipment of a type described in *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(d)*, and no vent from or opening into any hazardous space or zone defined by 5.3.1, other than the access under consideration.~~

~~(e)~~ ~~It is separated from the interior of any tank intended for recovered oil in accordance with *Pt 7, Ch 5, 5.5 Pressurisation 5.5.1(e)*.~~

5.5.2 A space having access to a hazardous area defined as **zone 2** may be regarded as non-hazardous if all following requirements are met:

(a) access is by means of a self-closing gastight steel door without any hold-back arrangement;

(b) it is maintained at an overpressure (minimum 0,25 mbar) relative to the external hazardous area by ventilation from a non-hazardous area;

(c) the relative air pressure within the space is continuously monitored and so arranged that:

  (i) in the event of loss of overpressure, an alarm is given; and

  (ii) a means of manual disconnection of electrical equipment not of a type suitable for **zone 2,** capable of being controlled from an attended station, is to be provided; where the means of disconnection, capable of being controlled from an attended station, is located within the space then it is to be of a type suitable for **zone 2**;

(d) any electrical equipment required to operate upon loss of overpressure (e.g. lighting fittings), is to be of a type suitable for **zone 2**;

(e) means are to be provided to prevent electrical equipment, other than of a type suitable for **zone 2**, being energised until the atmosphere within the space is made safe, by air changes of at least 10 times the capacity of the space; and

(f) it is separated by at least two gastight bulkheads from the interior of any tank intended for recovered oil.

~~5.5.3 A space having access to a hazardous space or zone, as defined under *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1*(c) to *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(j)*, and fulfilling the conditions given under *Pt 7, Ch 5, 5.5 Pressurisation 5.5.2(a)* to *Pt 7, Ch 5, 5.5 Pressurisation(e)* may be regarded, for the purposes of selection of electrical equipment, as equivalent to an open-deck hazardous area, such as defined under *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(k)*.~~

5.5.3 A space having access to a hazardous area defined as **zone 1** may be regarded as **zone 2** if all following requirements are met:

(a) access is by means of a self-closing gastight steel door without any hold-back arrangement;

(b) it is maintained at an overpressure relative to the external hazardous area by ventilation from a non-hazardous area;

(c) the relative air pressure within the space is continuously monitored and so arranged that:

  (i) in the event of loss of overpressure, an alarm is given; and;

  (ii) a means of manual disconnection of electrical equipment not of a type suitable for **zone 1**, capable of being operated from an attended station, is to be provided; where the means of disconnection, capable of being operated from an attended station, is located within the space then it is to be of a type suitable for **zone 1**;

(d) any electrical equipment required to operate upon loss of overpressure (e.g. lighting fittings), is to be of a type suitable for **zone 1**; and

(e) means are to be provided to prevent electrical equipment, other than of a type suitable for **zone 1**, being energised until the atmosphere within the space is made safe, by air changes of at least 10 times the capacity of the space.

5.6 Selection of electrical equipment for installation in hazardous areas

5.6.1 The installation of electrical equipment in hazardous areas is to be minimised ~~as far as is consistent with operational necessity and the provision of lighting, monitoring, alarm or control facilities enhancing the overall safety of the ship~~.

~~5.6.2 When electrical equipment is to be installed in hazardous areas, unless permitted otherwise by *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.3* or *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.4*, it is to be of a 'safe type', as listed below, certified or approved by a competent authority for Group IIA, temperature class T3. The construction and type testing is to be in accordance with IEC 60079: *Electrical Equipment for Explosive Gas Atmospheres*, or an acceptable and relevant National Standard.~~

- ~~Intrinsically safe Ex 'i'~~
- ~~Increased safety Ex 'e'~~
- ~~Flameproof Ex 'd'~~
- ~~Pressurised enclosure Ex 'p'~~
- ~~Powder filled Ex 'q'~~
- ~~Encapsulated Ex 'm'~~

~~5.6.3 Consideration may additionally be given to the use of equipment of the following types:~~

~~(a) Equipment such as control panels, protected by purging and pressurisation and capable of being verified by inspection as meeting the requirements of IEC 60079-2.~~
~~(b) Simple non-energy-storing apparatus having negligible surface temperature rise in normal operation, such as limit switches, strain gauges, etc., incorporated in intrinsically-safe circuits.~~
~~(c) Submersible pumps, having at least two independent methods of shutting down automatically in the event of low liquid level.~~
~~(d) Radio aerials having robust construction, meeting the relevant requirements of IEC 60079-15. Additionally, in the case of transmitter aerials, it is to be shown, by detailed study or measurement, or by limiting the peak radiated power and field strength to 1 W and 30 V/m, respectively, that they present negligible risk of inducing incendive sparking in adjacent structures or equipment.~~
~~(e) Electrical apparatus having a special type of protection (Ex's'), certified or approved by a competent authority.~~
~~(f) Electrical apparatus having the type of protection Ex'n' (or Ex'N'), that, in normal operation, is not capable of igniting a surrounding explosive gas atmosphere, and in which a fault capable of causing ignition is not likely to occur.~~

~~5.6.4 Equipment not meeting the requirements of *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.5* to *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.14* may be installed in hazardous zones or spaces, or locations rendered non-hazardous by ventilation or pressurisation, if not required to be energised during oil recovery operations, and not essential for the safety of the ship or crew. Such equipment is to be controlled by multi-pole switches or circuit breakers situated outside any hazardous area. Provision is to be made for the complete isolation of these circuits and locking the means of control in the off position.~~

~~5.6.5 In tanks and piping systems defined by *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(a)* and *Pt 7, Ch 5, 5.3 Hazardous zones and spaces(b)*, only the following electrical equipment will be permitted:~~

~~(a) Intrinsically-safe apparatus of category 'ia'.~~
~~(b) Simple apparatus, as defined under *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.3(b)*, incorporated in an intrinsically-safe circuit of category 'ia'.~~
~~(c) Submersible pumps, as defined under *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.3(c)*.~~
~~(d) Ex's' apparatus, certified for use in Zone 0, as defined by IEC 60079-10.~~
~~(e) Cable required for the operation of the equipment installed.~~

~~5.6.6 In spaces adjacent to tanks, as defined by *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(c)*, with no mechanical ventilation, only the following electrical equipment will be permitted:~~

~~(a) That described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.5(a)*, *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas(b)*, *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas(d)* and *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas(e)*.~~
~~(b) Ex'd' lighting fittings.~~
~~(c) Ex'p' lighting fittings of either the air-driven type, or pressurised from an external source of protective gas and arranged to be de-energised automatically on loss of pressurisation.~~
~~(d) Gas detector heads having sinter-type flametrap protection, included within an intrinsically-safe circuit, all of which is to be certified as a system.~~
~~(e) Ex'd' alarm sounders, without internal sparking contacts.~~
~~(f) Cables for impressed current cathodic protection systems (for external hull protection only) installed in heavy gauge steel pipes with gastight joints up to the upper deck; the arrangements are to comply with *Pt 3, Ch 2, 3.5 External hull protection 3.5.3*.~~
~~(g) Through runs of cables, installed in heavy gauge steel pipes with gastight joints.~~

~~The electrical equipment described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas(b)*, *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas(c)* and *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas(e)* will be permitted only where personnel are required to have access to the space during oil recovery operations.~~

~~5.6.7 In spaces adjacent to tanks, as defined by *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(c)* having mechanical ventilation, and in spaces and zones containing piping systems, equipment, etc., or close to vents, flanges, etc., and other zones as defined by *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(d)* to *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(j)*, only the following electrical equipment will be permitted:~~

~~(a) That described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.6*.~~
~~(b) Intrinsically-safe apparatus of category ‘ib’.~~
~~(c) Simple apparatus, as defined under 5.6.3(b), incorporated in an intrinsically-safe circuit of category ‘ib’.~~
~~(d) Other apparatus certified as Ex’e’, Ex’d’, Ex’q’, Ex’m’ or Ex’s’.~~
~~(e) Pressurised equipment, certified Ex’p’, or as described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.3(a)*, arranged to be de-energised automatically on loss of pressurisation.~~
~~(f) Through runs of cable in spaces and zones described in *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(d)* to *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(j)* only.~~

~~5.6.8 In zones defined by *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(k)* and *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(l)*, only the following electrical equipment will be permitted:~~
~~(a) That described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.7*.~~
~~(b) Pressurised equipment, certified Ex’p’, or as described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.3(b)*, arranged to give an audible and visual alarm at a manned station in the event of loss of pressurisation.~~
~~(c) Equipment as described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.3(d)* and *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.3(f)*.~~

5.6.2 When electrical equipment is to be installed in hazardous areas, it is to be of a type appropriate for Group IIA, temperature class T3 and compliant with the relevant Parts of IEC 60079: *Explosive atmospheres*, or an acceptable and relevant National Standard, unless permitted otherwise by one of the following;

- *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.4;*
- *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.5;* or
- *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.6.*

5.6.3 Equipment for **zone 0** or **zone 1**, with the exception of simple apparatus as defined in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.4* or *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.5*, is to be certified or approved by a National or other appropriate authority. Equipment without independent certification or approval may be considered for installation in **zone 2**.

5.6.4 In **zone 0**, the following may be considered:

- intrinsically safe, category ‘a’ (Ex ‘ia’);
- simple electrical apparatus and components (for example thermocouples, photocells, strain gauges, junction boxes, switching devices), included in intrinsically safe circuits of category ‘ia’,compliant with IEC 60079-14: *Explosive atmospheres — Part 14: Electrical installations design, selection and erection*; and
- submersible pumps, having at least two independent methods of shutting down automatically in the event of
- low liquid level.

Note Oil recovery equipment deployed over an oil spill pool is to be appropriate for **zone 0**.

5.6.5 In **zone 1**, the following may be considered:
(a) apparatus permitted within **zone 0**;
(b) intrinsically safe, category ‘b’ (Ex ‘ib’);
(c) simple apparatus as defined above, included in intrinsically safe circuits of category ‘ib’;
(d) increased safety (Ex ‘e’);
(e) flameproof (Ex ‘d’);
(f) pressurised enclosure (Ex ‘p’);
(g) powder filled (Ex ‘q’); or
(h) encapsulated (Ex ‘m’).

5.6.6 In **zone 2**, the following may be considered:
(a) apparatus permitted within **zone 1**;
(b) type of protection ‘n’ or ‘N’;
(c) equipment such as control panels, protected by purging and pressurisation and capable of being verified by inspection as meeting the requirements of IEC 60079-2: *Explosive atmospheres – Part 2: Equipment protection by pressurized enclosures "p"*; or
(d) radio aerials having robust construction, meeting the relevant requirements of IEC 60079-15: *Explosive atmospheres – Part 15: Equipment protection by type of protection "n"*. Additionally, in the case of transmitter aerials, it is to be shown, by detailed study or measurement, or by limiting the peak radiated power and field strength to 1 W and 30 V/m respectively, that they present negligible risk of inducing incendive sparking in adjacent structures or equipment.

5.6.7 Consideration may also be given to other types of protection, selected in accordance with the requirements of IEC 60079-14: *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*.

5.6.8 Electrical equipment not essential for the safety or operation of the ship and which is not of a type providing protection against ignition of the recovered oil gases is to be completely disconnected and protected against unauthorised re-connection. Disconnection is to be made outside the hazardous areas and be effected with isolating links or lockable switches.

~~5.6.9 Electrical installations in enclosed or semi-enclosed spaces, as described in *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(m)*, are to comply with the requirements for the space or zone into which the opening leads, unless ventilated in accordance with *Pt 7, Ch 5, 5.4 Ventilation 5.4.1* or *Pt 7, Ch 5, 5.4 Ventilation 5.4.2*.~~

~~5.6.10 Electrical installations in enclosed or semi-enclosed spaces, ventilated as described in *Pt 7, Ch 5, 5.4 Ventilation 5.4.1*, are to comply with the requirements for hazardous zones, as described in *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(e)* to *Pt 7, Ch 5, 5.3 Hazardous zones and spaces 5.3.1(l)*, within the radii or distances from adjacent sources of hazard or sources within the space specified by these paragraphs. Equipment within a radius of 3 m from any ventilation outlet of such a space is to be of a type described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.8*. Equipment not of a type described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.7* is to be provided with a means of disconnection capable of being controlled from an attended station in the event of ventilation failure. Where the means of disconnection is located within the space, then it is to be of a 'safe type'~~.

~~5.6.11~~ 5.6.9 Electrical installations in machinery spaces adjacent to recovered oil tanks, where permitted by *Pt 7, Ch 5, 5.3 Structural arrangement 3.1.7*, are to ~~comply with the requirements of 5.6.10, and the additional requirement that equipment~~ be of a type described in 5.6.6 within 0,45 m of the tank bulkhead or the bottom of the space ~~is to be of a type described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.8*~~.

~~5.6.12 In pressurised spaces defined by *Pt 7, Ch 5, 5.5 Pressurisation 5.5.1*, electrical equipment not of a type described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.8* is to be automatically disconnected in the event of loss of overpressure. Other equipment is to be provided with a means of disconnection capable of being controlled from an attended station in the event of loss of overpressure. Where the means of disconnection is located within the space, it is to be of a 'safe type'. Emergency lighting, pressure monitoring equipment and any alarm sounders or lights are to be of types described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.6*.~~

~~5.6.13 In pressurised spaces defined by *Pt 7, Ch 5, 5.5 Pressurisation 5.5.2*, any equipment not of a type described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.8* is to be provided with a means of disconnection capable of being controlled from an attended station in the event of loss of overpressure.~~

~~5.6.14 In pressurised spaces defined by *Pt 7, Ch 5, 5.5 Pressurisation 5.5.3*, only electrical equipment as described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.8* may be permitted. Any equipment that is not of a type described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.7* is to be provided with a means of disconnection capable of being controlled from an attended station in the event of loss of overpressure. Emergency lighting, pressure monitoring equipment and any alarm sounders or lights are to be of types described in *Pt 7, Ch 5, 5.6 Selection of electrical equipment for installation in hazardous areas 5.6.6*.~~

Part 7, Chapter 12
Passenger and Crew Accommodation Comfort

■ *Section 2*
Noise

2.2 Passenger accommodation and public spaces

Table 12.2.1 Passenger ships - Maximum noise levels in dB(A)

Location		Acceptance Numeral		
		1	2	3
Passenger cabins:	Standard ~~Superior~~	49	52	55
	Superior	45	47	50
Public spaces:	Excluding shops	55	58	62
	Shops	60	62	65
Medical centre~~:~~		50	55	60
Theatre/auditorium		50	55	60
Open deck recreation areas (excluding swimming pools and similar)		67	72	72
Swimming pools and similar		70	75	75

Note 1. The levels may be exceeded by 5dB(A) within 3 m of a ventilation inlet/outlet or machinery intake/uptake on open decks.

Note 2. The levels may be exceeded by 3dB(A) in accommodation above the propellers for three decks above the mooring deck.

Note 3. The levels for open deck recreation areas refer to ship generated noise only. On open deck spaces the noise generated from the effects of wind and waves can be considered separately to limits agreed between the Builder and Owner and advised to LR for the trial conditions.

■ *Section 4*
Testing

4.2 Test conditions

(*Part only shown*)
4.2.4 The test conditions required for the vibration and noise measurements are to be in accordance with the following conditions:
(i) For passenger ships, intermittently run equipment such as transverse propulsion units are to be operated at 60 per cent and for all other ships 40 per cent of their rated power for additional measurements in surrounding ship areas.

Part 8, Chapter 1
Application

■ *Section 1*
Scope

1.1 General

Table 1.1.1 Ice and cold operations

Reference			Conditions	Description	Notation
Ice operations					
Chapter 2	Section 1		Application		
	Section 2 Section 3	Hull Machinery	General requirements	Applicable to all ice classes	
	Section 4 Section 5	Hull Machinery	Light and very light ice conditions	For ships with length less than 150 m	**Ice Class 1E**
				Hull strengthening in forward region only	**Ice Class 1D**
	Section 6 Section 7	Hull Machinery	First-year ice conditions	*Finnish-Swedish Ice Class Rules*	**Ice Class 1C FS**
					Ice Class 1B FS
					Ice Class 1A FS
					Ice Class 1AS FS
	Section 8 Section 9	Hull Machinery		*Finnish-Swedish Ice Class Rules* with enhanced engine power for icebreaking capability	**Ice Class 1C FS(+)**
					Ice Class 1B FS(+)
					Ice Class 1A FS(+)
					Ice Class 1AS FS(+)
	Section 10 Section 11	Hull Machinery	Multi-year ice conditions	IACS Polar Ship Rules	**Ice Class PC7**
					Ice Class PC6
					Ice Class PC5
					Ice Class PC4
					Ice Class PC3
					Ice Class PC2
					Ice Class PC1
					Icebreaker
	Section 12	Hull Machinery		IACS Polar Ship Rules with enhanced scantlings derived from operational scenarios	**Icebreaker(+)**
Cold operations					
Provisional Rules for the Winterisation of Ships	Section 1		Application		
	Section 2	Hull materials	Low temperature operations	Hull construction materials	**Winterisation H(~~T~~*t*)**
	Section 3	Equipment and systems	Low temperature operations	~~Short duration~~ Mild extent of winterisation	**Winterisation C(~~T~~*t*)**
				~~Seasonal duration~~ Moderate extent of winterisation	**Winterisation B(~~T~~*t*)**
				~~Prolonged duration~~ Extensive extent of winterisation	**Winterisation A(~~T~~*t*)**
	Section 3 Section 4	Equipment		Materials of exposed equipment	**Winterisation M** **Winterisation Mn**
	Section 9	Systems		Winterisation system redundancy	**Winterisation WR**
	Section 10	Stability	Operation in areas of ice accretion	Ice accretion loading	**Winterisation S(C)** **Winterisation S(B)** **Winterisation S(A)**
	Section 11	Equipment		Ice removal arrangements	**Winterisation IR**
	Section 12	Equipment and systems	Direct design for low temperature operations		**Winterisation D(*t*)**

■ *Section 2*
Ice environment

2.2 Definitions

Table 1.2.1 WMO definition of ice conditions

Ice conditions		**Ice thickness range**
Old ice	Multi-year	>2,5 m
	Second-year	<2,5 m
First-year ice	Thick first-year	>1,2 m
	Medium first-year	0,7 - 1,2 m
	Thin first-year, second stage	0,5 - 0,7 m
	Thin first-year, first stage	0,3 - 0,5 m
	Grey-white	0,15 - 0,3 m
	Grey	0,1 - 0,15 m
Nilas		<0,1 m

■ *Section 3*
Air environment

3.1 Air temperature

3.1.2 The ~~average external design~~ airmean daily low temperature is to be taken as the lowest mean daily ~~average~~ low air temperature in the area of operation. For seasonally restricted service the lowest value within the period of operation applies:
where

Mean = statistical mean over a minimum of 10 years
Average = average during one day and one night
Lowest = lowest during the year or season
MDHT = Mean Daily High Temperature
MDAT = Mean Daily Average Temperature
MDLT = Mean Daily Low Temperature

Figure 1.3.1 Air temperature shows the definition graphically.

3.1.3 The ~~lowest~~ external design air temperature is to be taken as the lowest mean daily low~~est~~ air temperature in the area of operation for the season of operation (T_y) minus 10 degrees Celsius ($t = T_y – 10$). For example: $T_y = -20$°C, $t = -30$°C. ~~Where reliable environmental records for contemplated operational areas exist, the lowest external design air temperature may be obtained after the exclusions of all recorded values having a probability of occurrence of less than 3 per cent.~~

3.1.4 Lowest mean daily ~~average~~ low air temperatures for the Arctic and Antarctic are provided in *Figure 1.3.2 Lowest mean daily air temperature for the Arctic* and *Figure 1.3.3 Lowest mean daily air temperature for the Antarctic*.

Part 8, Chapter 2
Ice Operations – Ice Class

■ *Section 1*
Strengthening requirements for navigation in ice – Application of requirements

1.1 Additional strengthening

1.1.4 The vertical extent of the ice strengthening is related to the upper ice waterline ~~light~~ and lower ice ~~load~~ waterline~~s~~, which are defined in *Pt 8, Ch 2, 2.2 Definitions*. The maximum and minimum draughts at the fore, amidships and aft ends (for the lowest ice class) ~~will~~ are to be stated on the Certificate of Class.

1.1.5 ~~The~~ For ships that comply with the requirements of the *Finnish-Swedish Ice Class Rules*, the installed and required minimum engine output (for the lowest ice class), *see Pt 8, Ch 2, 7 Machinery requirements for first-year ice conditions – Ice Classes 1ASFS, 1A FS, 1B FS and 1C FS*, will be stated on the Certificate of Class.

1.4 Application for multi-year ice conditions

1.4.1 The requirements for strengthening for navigation in ice, as given in *Pt 8, Ch 2, 10 Hull strengthening requirements for navigation in multi-year ice conditions – Ice Classes PC1, PC2, PC3, PC4, PC5, PC6, PC7 and Icebreaker* and *Pt 8, Ch 2, 1 Machinery strengthening requirements for navigation in multi-year ice conditions – Ice Classes PC1, PC2, PC3, PC4, PC5, PC6 and PC7*, are intended for ships operating in multi-year ice in Arctic or Antarctic ice conditions under their own power and constructed of steel~~, except icebreakers,~~ ~~*see Pt 8, Ch2, 1.5 Icebreakers 1.5.1*~~.

Existing paragraph 1.4.2 has been renumbered 1.4.5.

1.4.2 For ships assigned a Polar Class (**PC**) notation, the hull form and propulsion power are to be such that the ship can operate independently and at a continuous speed in a representative ice condition, as defined in *Table 2.1.1 Polar class descriptions* for the corresponding Polar Class. For ships and ship-shaped units which are intentionally not designed to operate independently in ice, such operational intent or limitations will be explicitly stated on the Certificate of Class.

1.4.3 For ships of polar classes **PC1**, **PC2**, **PC3**, **PC4** and **PC5**, bows are to be of icebreaking form with bow angles generally within the range specified in *Pt 8, Ch 2, 10.2 Design ice loads – general 10.2.5*. Other bow forms are to be specially considered, *see Pt 8, Ch 2, 10.2 Design ice loads – general 10.2.9*. Bows with vertical sides and bulbous bows are generally to be avoided.

1.4.4 For ships of polar classes **PC6** and **PC7** that are designed with a bow with vertical sides or with a bulbous bow, operational limitations (restricted from intentional ramming) in the design conditions are to be stated on the Certificate of Class.

Existing paragraphs 1.4.3 and 1.4.4 have been renumbered 1.4.6 and 1.4.7.

1.5 Icebreakers

1.5.1 Sea-going ships specially designed for icebreaking duties will be assigned the ship type notation '**Icebreaker'** in addition to the special features notation appropriate to the degree of ice strengthening provided. 'Icebreaker' refers to any ship having an operational profile that includes escort or ice management functions, having powering and dimensions that allow it to undertake aggressive operations in ice-covered waters, and having a class certificate endorsed with this notation. The additional ship type notations may be assigned as follows:

Icebreaker	Refers to a ship having an operational profile that includes escort, research or support functions, having power and dimensions that allow it to undertake aggressive operations in ice covered waters, *see Pt 8, Ch 2, 10.8 Hull area factors 10.8.4*.
Icebreaker(+)	Refers to a ship for which the powering and ~~dimensions~~ scantlings of the hull structure and propulsion machinery necessary to undertake the operational profile as determined in the ship specific scenario document ~~by selection of a primary function~~ have been assessed, *see Pt 8, Ch 2, 12 Requirements for Icebreaker(+).*

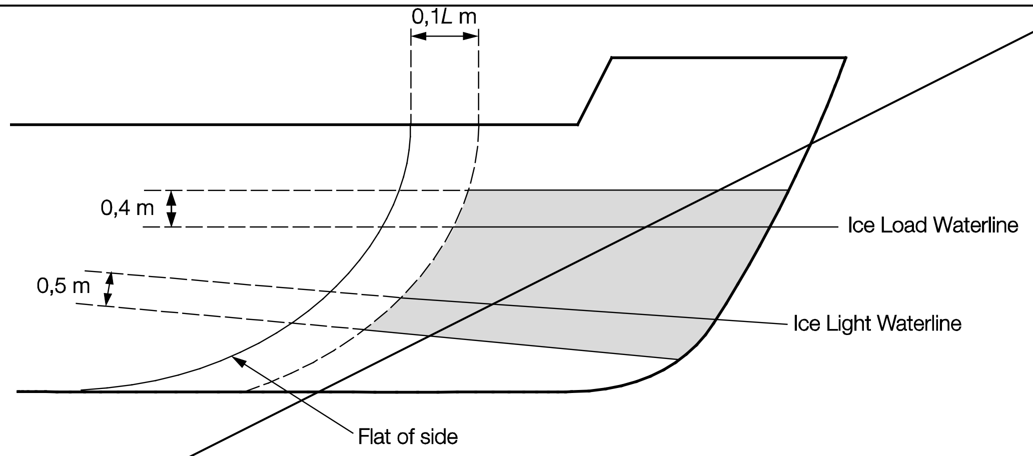
■ *Section 2*
General hull requirements for navigation in ice – All ice classes

2.3 Rudder and steering arrangements

2.3.1 Rudder stoppers working on the rudder blade or rudder head are to be fitted to ships assigned the notations **Ice Class 1AS FS**, **1AS FS(+)**, **1A FS**, **1A FS(+)** and to ships assigned Polar Class (**PC**) notations.

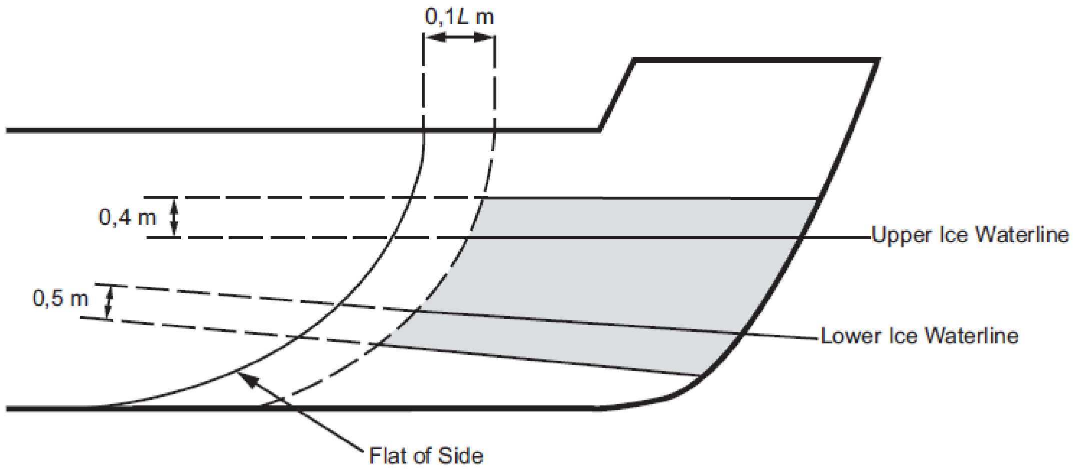
■ *Section 4*
Hull requirements for light ice conditions – Ice Classes 1D and 1E

4.3 Shell plating



~~Ice Load Waterline and Ice Light Waterline are defined in 7.2~~
~~*L*, as defined in Ch 1,6.1~~

~~Figure 2.4.1 Extent of application of plating requirements~~



Upper Ice Waterline and Lower Ice Waterline are defined in *Pt 8, Ch 2, 2.2 Definitions*
L, as defined in *Pt 3, Ch 1, 6.1 Principal particulars*

Figure 2.4.1 Extent of application of plating requirements

4.6 Stern frame and rudder – Ice Class 1D

4.6.1 The rudder and stern frame scantlings are to be in accordance with *Pt 8, Ch 2, ~~6.5 Stern~~ 6.7 Rudder and steering arrangements*. ~~However, the ship's speed need not be taken greater than 14 knots. The hull form factor and rudder profile coefficients are to be taken as 1,0.~~

■ *Section 6*
Hull requirements for first-year ice conditions – Ice Classes 1AS FS, 1A FS, 1B FS, 1C FS and 1D

6.7 Rudder and steering arrangements

6.7.2 For double plate rudders, the minimum thickness of plating and horizontal and vertical webs ~~in the main ice belt zone~~ is to be determined as for shell plating in the ~~aft~~ midbody region. For the horizontal and vertical webs, the corrosion-abrasion increment, *c*, need not be added. For **Ice Class 1D**, the minimum thickness of plating and webs, of double plate rudders and the extent of application are to be determined as for those in **Ice Class 1C FS**.

■ *Section 10*
Hull strengthening requirements for navigation in multi-year ice conditions – Ice Classes PC1, PC2, PC3, PC4, PC5, PC6, PC7 and Icebreaker

10.1 Hull Areas

Existing paragraph 10.1.5 has been renumbered 10.1.6.

10.1.5 The forward boundary of the stern region is to be at least a distance *Z* from the aft perpendicular, where *Z* is 0,7*b* or 0,15*L* whichever is greater. *b* is the distance from the aft perpendicular to the maximum half breadth at the UIWL and *L* is defined in *Pt 8, Ch 2, 10.4 Bow area 10.4.3*.

~~10.1.6~~ 10.1.7 If a ship is intended to operate astern in ice regions, the aft section of the ship is to be designed based on the bow and bow intermediate hull area requirements. *See* the *Provisional Rules for the Classification of Stern First Ice Class Ships, November 2011.*

10.1.8 In addition to *Figure 2.10.1 Extent of hull areas,* if the ship is assigned the additional notation **Icebreaker** the forward boundary of the stern region is to be at least 0,04*L* forward of the section where the parallel ship side at the upper ice waterline (UIWL) ends.

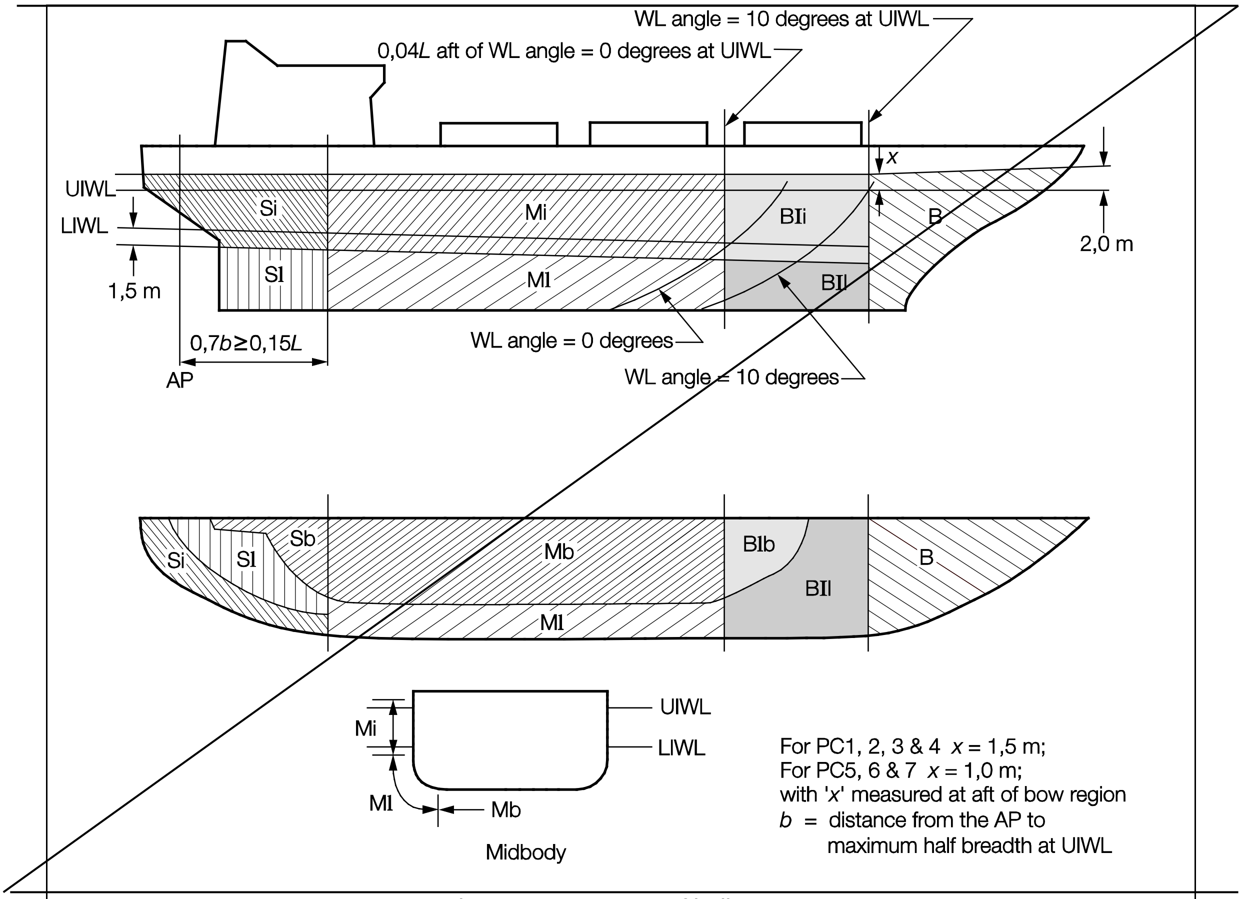

WL angle = 10 degrees at UIWL
0,04L aft of WL angle = 0 degrees at UIWL
x
UIWL
LIWL
1,5 m
Si
Mi
BIi
B
2,0 m
Sl
Ml
BIl
0,7b≥0,15L
AP
WL angle = 0 degrees
WL angle = 10 degrees
Si
Sl
Sb
Mb
BIb
BIl
B
Ml
UIWL
LIWL
Mi
Ml
Mb
Midbody
For PC1, 2, 3 & 4 x = 1,5 m;
For PC5, 6 & 7 x = 1,0 m;
with 'x' measured at aft of bow region
b = distance from the AP to
maximum half breadth at UIWL

Figure 2.10.1 Extent of hull areas

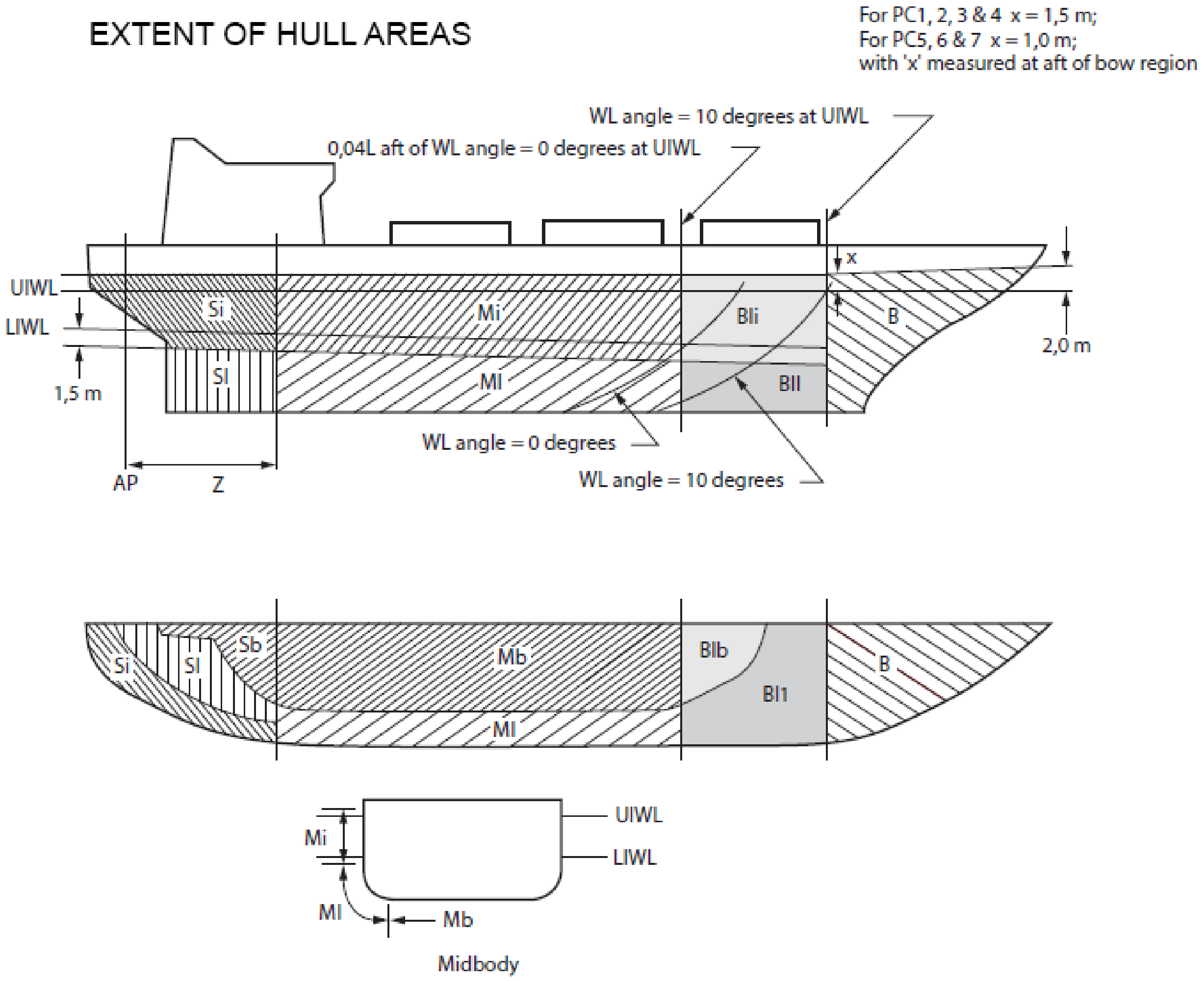

EXTENT OF HULL AREAS
For PC1, 2, 3 & 4 x = 1,5 m;
For PC5, 6 & 7 x = 1,0 m;
with 'x' measured at aft of bow region
WL angle = 10 degrees at UIWL
0,04L aft of WL angle = 0 degrees at UIWL
UIWL
LIWL
1,5 m
Si
Sl
Mi
Ml
Bli
Bll
B
x
2,0 m
WL angle = 0 degrees
WL angle = 10 degrees
AP
Z
Sb
Mb
Blb
Bl1
Mi
Ml
Mb
UIWL
LIWL
Midbody

Figure 2.10.1 Extent of hull areas

10.2 Design ice loads – General

10.2.4 For polar classes **PC6** and **PC7** the ice load parameters, P_a, *b* and *w*, determined as a function of the bow shape in bow region, *B*, are also to be applied to bow intermediate icebelt region, *Bl*i.

Existing paragraph 10.2.4 has been renumbered 10.2.5.

Existing paragraph 10.2.5 has been renumbered 10.2.9.

10.2.6 Design ice forces calculated according to *Pt 8, Ch 2, 10.4 Bow area 10.4.3* are applicable for icebreaking bow forms where the buttock angle γ at the stem is positive and less than 80°, and the normal frame angle β' at the centre of the foremost sub-region, as defined in *Figure 2.10.2 Definition of hull angles*, is greater than 10°.

10.2.7 Design ice forces calculated according to *Pt 8, Ch 2, 10.4 Bow area 10.4.4* are applicable for ships of polar classes **PC6** and **PC7** and have a bow form with vertical sides. This includes bows where the normal frame angle β' at the considered sub-regions, as defined in *Figure 2.10.2 Definition of hull angles* are between 0 and 10°.

10.2.8 For ships of polar classes **PC6** and **PC7** with bulbous bows the design ice forces on the bow are to be determined according to *Pt 8, Ch 2, 10.4 Bow area 10.4.4*. In addition, the design forces are not to be taken less than those given in *Pt 8, Ch 2, 10.4 Bow area 10.4.3*, assuming f_a = 0,6 and *AR* = 1,3.

~~10.2.5~~ 10.2.9 ~~Design ice forces calculated according to *Pt 8, Ch 2 10.3 Glancing impact load characteristics* are only valid for vessels with icebreaking forms.~~ For ships with bow forms other than those defined in *Pt 8, Ch 2, 10.2 Design ice loads – General 10.2.6* to *Pt 8, Ch 2, 10.2 Design ice loads – General 10.2.8*, design ice forces are to be specially considered.

~~10.2.6~~ 10.2.10 Ship structures that are not directly subjected to ice loads may still experience inertial loads of stowed cargo and equipment resulting from ship/ice interaction. These inertial loads are to be considered in the design of these structures.

10.3.1 Glancing impact load characteristics

10.3.1 The parameters defining the glancing impact load characteristics are reflected in the class factors listed in *Table 2.10.1 Class factors for icebreaking bow forms* and *Table 2.10.2 Class factors for vertical side bow forms*.

(*Part only shown*)

Table 2.10.1 Class factors for icebreaking bow forms

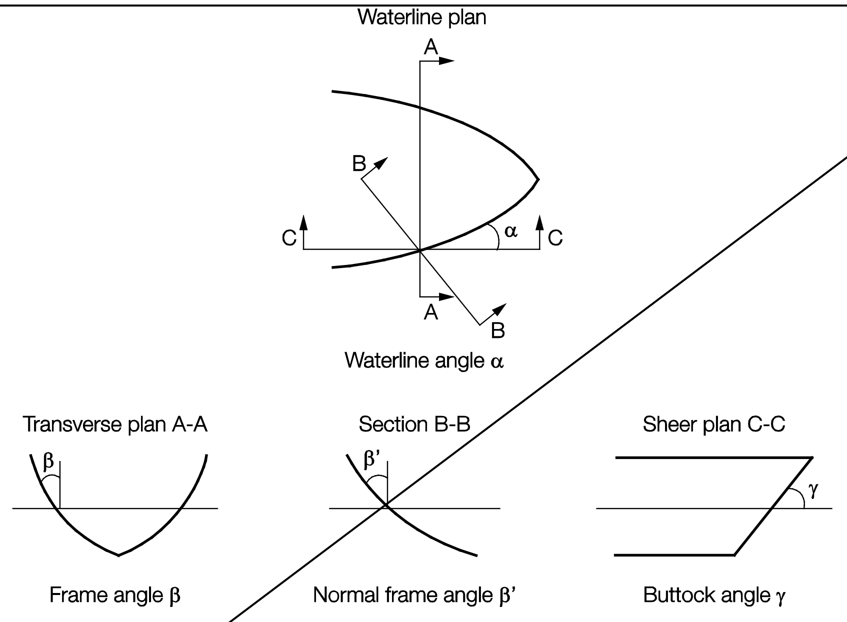
Table 2.10.2 Class factors for vertical side bow forms

Polar Class	Crushing failure class factor	Line load class factor	Pressure class factor
	C_{CV}	C_{QV}	C_{PV}
PC6	3,43	2,82	0,65
PC7	2,60	2,33	0,65

Existing Tables 2.10.2 to 2.10.12 have been renumbered 2.10.3 to 2.10.13.

10.4 Bow area

10.4.1 In the bow area, the force, *F*, line load, *Q*, pressure, *P*, and load patch aspect ratio, *AR*, associated with the glancing impact load scenario are functions of the hull angles measured at the upper ice waterline, UIWL. The influence of the hull angles is captured through calculation of a bow shape coefficient, *fa*. The hull angles are defined in *Figure 2.10.2 Definition of hull angles*.



where

β' = normal frame angle at upper ice waterline, in degrees

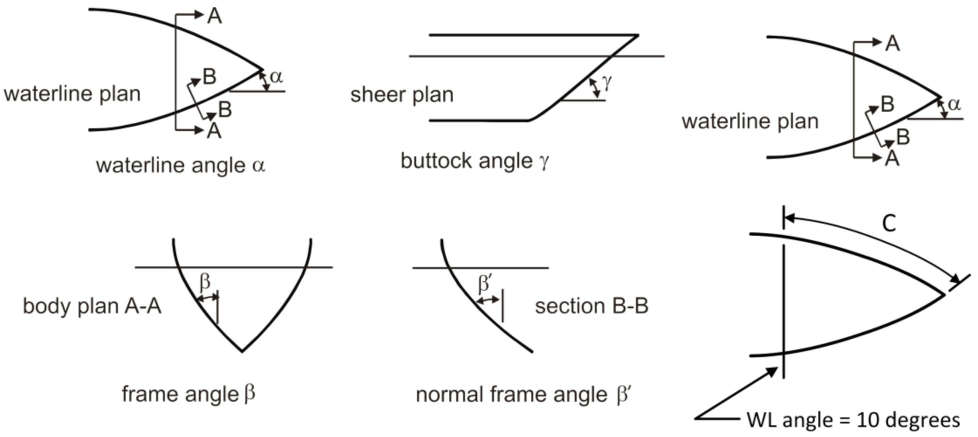
α_S = upper ice waterline angle, in degrees

γ = buttock angle at upper ice waterline (angle of buttock line measured from horizontal), in degrees

$$\tan(\beta) = \frac{\tan(\alpha)}{\tan(\gamma)}$$

$$\tan(\beta') = \tan(\beta)\cos(\alpha)$$

~~Figure 2.10.2 Definition of hull angels~~



where

β' = normal frame angle at upper ice waterline, in degrees

α = upper ice waterline angle, in degrees

γ = buttock angle at upper ice waterline (angle of buttock line measured from horizontal), in degrees

$\tan(\beta) = \dfrac{\tan(\alpha)}{\tan(\gamma)}$

$\tan(\beta') = \tan(\beta)\cos(\alpha)$

C = waterline length of the bow region

Figure 2.10.2 Definition of hull angles

10.4.2 The waterline length of the bow region, *C*, is generally to be divided along the UIWL into four sub-regions of equal length. The force, *F*, line load, *Q*, pressure, *P*, and load patch aspect ratio, *AR*, are to be calculated with respect to the mid - length position of each sub-region (each maximum of *F*, *Q* and *P* is to be used in the calculation of the ice load parameters P_a, *b* and *w*).

(*Part only shown*)

10.4.3 The bow area load characteristics for icebreaking bow forms, as defined in *Pt 8, Ch 2, 10.2 Design ice loads – General 10.2.6*, are determined as follows:

(a) The shape coefficient, fa_i, is to be taken as:

where

$$fa_{i,1} = \left(0{,}097 - 0{,}68\left(\frac{x}{L} - 0{,}15\right)^2\right)\frac{\alpha_i}{\sqrt{\beta'_i}}$$

$$fa_{i,2} = \frac{1{,}2\,C_F}{\sin(\beta'_i)\,C_C\,\Delta^{0{,}64}}$$

$fa_{i,3}$ = 0,60

i = sub-region considered

L = ship length as defined in *Pt 3, Ch 1, 6.1 Principal particulars 6.1.1*, but measured at the upper ice waterline (UIWL), in metres

x = distance from the forward perpendicular (FP) to station under consideration, in metres

~~α~~α_i = waterline angle, in degrees, *see Figure 2.10.2 Definition of hull angles*

~~β'~~β'_i = normal frame angle, in degrees, *see Figure 2.10.2 Definition of hull angles*

Δ = ship displacement, in kilo tonnes, not to be taken less than 5

C_C = crushing failure class factor from *Table 2.10.1 Class factors for icebreaking bow forms*

C_F = flexural failure class factor from *Table 2.10.1 Class factors for icebreaking bow forms*

(b) Force, F_i:

$F_i = fa_i\,C_C\,\Delta^{0{,}64}$ MN

where

i = sub-region considered

fa_i = shape coefficient of sub-region, *i*

C_C = crushing failure class factor from *Table 2.10.1 Class factors for icebreaking bow forms*

Δ = ship displacement, in kilo tonnes, not to be taken less than 5

(d) Line load, Q_i :

$$Q_i = \frac{F_i^{0,61} C_D}{AR_i^{0,35}} \quad \text{MN/m}$$

where

i = sub-region considered

F_i = force of sub-region *i*, in MN

C_D = load patch dimensions class factor from *Table 2.10.1 Class factors for icebreaking bow forms*

AR_i = load patch aspect ratio of sub-region *i*

(e) Pressure, P_i :

$$P_i = F_\mathrm{i}^{0.22} C_D^2 AR_\mathrm{i}^{0,3} \quad \text{MPa}$$

Where

~~I~~i = sub-region considered

F_i = force of sub-region *i*, in MN

C_D = load patch dimensions class factor from *Table 2.10.1 Class factors for icebreaking bow forms*

AR_i = load patch aspect ratio of sub-region *i*

10.4.4 The bow area load characteristics for bow forms with vertical sides, as defined in *Pt 8, Ch 2, 10.2 Design ice loads – General 10.2.7*, are determined as follows:

(a) The shape coefficient, fa_i, is to be taken as:

$$fa_\mathrm{i} = \frac{\alpha_i}{30}$$

where

i = sub-region considered

α = waterline angle, in degrees, *see Figure 2.10.2 Definition of hull angles*

(b) Force, F_i:

$$F_\mathrm{i} = fa_i C_\mathrm{CV} \Delta^{0,47} \text{ MN}$$

where

i = sub-region considered

fa_i = shape coefficient of sub-region, *i*

C_CV = crushing failure class factor from *Table 2.10.2 Class factors for vertical side bow forms*

Δ = ship displacement, in kilo tonnes, not to be taken less than 5

(c) Line load, Q_i :

$$Q_i = F_i^{0.22} C_\mathrm{QV} \text{ MN/m}$$

where

i = sub-region considered

F_i = force of sub-region *i*, in MN

C_QV = line load class factor from *Table 2.10.2 Class factors for vertical side bow forms*

(d) Pressure, P_i :

$$P_\mathrm{i} = F_i^{0.56} C_\mathrm{PV} \text{ MPa}$$

where

i = sub-region considered

F_i = force of sub-region *i*, in MN

C_PV = pressure class factor from *Table 2.10.2 Class factors for vertical side bow forms*

10.5 Hull areas other than the bow

(*Part only shown*)

10.5.1 In the hull areas other than the bow, the force, F_NB, and line load, Q_NB, used in the determination of the load patch dimensions, b_NB, w_NB, and design pressure, P_a, are determined as follows:

(a) Force, F_NB:

where

C_C = crushing force class factor from *Table 2.10.1 Class factors for icebreaking bow forms*

Δ_F = ship displacement factor

= $\Delta^{0.64}$ if $\Delta \le C_\mathrm{DI}$

= $C_\mathrm{DI}^{0,64} + 0,10\,(\Delta - C_\mathrm{DI})$ if $\Delta > C_\mathrm{DI}$

Δ = ship displacement, in kilo tonnes, not to be taken less than 10

C_DI = displacement class factor from *Table 2.10.1 Class factors for icebreaking bow forms*

(b) Line Load, Q_{NB} :

$$Q_{NB} = 0{,}639 F_{NB}^{0{,}61} \; C_D \text{ MN/m}$$

where

F_{NB} = force from *Pt 8, Ch 2, 10.5 Hull areas other than the bow ~~10.5.1~~ 10.5.1(a)*, in MN
C_D = load patch dimensions class factor from *Table 2.10.1 Class factors for icebreaking bow forms*

10.6 Design load patch

10.6.1 In the bow area, and the bow Intermediate Icebelt area for ships with class notation **PC6** and **PC7**, the design load patch has dimensions of width, w_B, and height, b_B, defined as follows:

$$w_B = \frac{F_B}{Q_B} \text{ m}$$

$$b_B = \frac{Q_B}{P_B} \text{ m}$$

where

F_B = maximum F_i in the bow area, in MN
Q_B = maximum Q_i in the bow area, in MN/m
P_B = maximum P_i in the bow area, in MPa

(Part only shown)

10.6.2 In hull areas other than those covered by *Pt 8, Ch 2, 10.6 Design load patch 10.6.1*, the design load patch has dimensions of width, w_{NB}, and height, b_{NB}, defined as follows:

$$\cancel{w_{NB} = \frac{F_{NB}}{Q_{NB}} \text{ m}} \qquad w_{NB} = \frac{F_{NB}}{Q_{NB}} \text{ m}$$

$$\cancel{b_{NB} = \frac{w_{NB}}{3{,}6} \text{ m}} \qquad b_{NB} = \frac{w_{NB}}{3{,}6} \text{ m}$$

where

F_{NB} = force determined using *Pt 8, Ch 2, 10.5 Hull areas other than the bow 10.5.1(a)*, in MN
Q_{NB} = line load determined using *Pt 8, Ch 2, 10.5 Hull areas other than the bow 10.5.1(b)*, in MN/m

10.7 Pressure within the design load patch

10.7.2 Areas of higher, concentrated pressure exist within the load patch. In general, smaller areas have higher local pressures. Accordingly, the peak pressure factors listed in *Table ~~2.10.2~~ 2.10.3 Peak pressure factors* are used to account for the pressure concentration on localised structural members.

Table ~~2.10.2~~ 2.10.3 Peak pressure factors

Structural member		Peak pressure factor, K_i
Plating	Transversely framed	$K_p = (1{,}8 - s) \geq 1{,}2$
	Longitudinally framed	$K_p = (2{,}2 - 1.2s) \geq 1{,}5$
Frames in transverse framing systems	With load distributing stringers *see* Note 1	$K_t = (1{,}6 - s) \geq 1{,}0$
	With no load distributing stringers *see* Note 1	$K_t = (1{,}8 - s) \geq 1{,}2$
Frames in bottom structures		$K_s = 1$
Load carrying stringers *see* Note 2 Side ~~and bottom~~ longitudinals Web frames		$K_s = 1$ if $S_w \geq 0{,}5w$ $K_s = 2 - \frac{2S_w}{w}$ if $S_w < 0{,}5w$
Symbols		
s	=	frame or longitudinal spacing, in metres
S_w	=	web frame spacing, in metres
w	=	ice load patch width, in metres
Note 1. Load distributing stringers are intercostal. Load distributing stringer web height h_{lds} is to be at least 80 per cent of the adjacent main frame web height ($h_{lds} \geq 0{,}8h$). Note 2. Load carrying stringers are considered as continuous strength members in accordance with *Pt 8, Ch 2, 10.13 Framing – Web frame and load carrying stringers*. Generally load carrying stringer web height $h_{lcs} \geq 2h$.		

10.8 Hull area factors

10.8.3 Due to their increased manoeuvrability, ships having propulsion arrangements with ~~azimuthing~~ azimuth thruster(s) or podded propellers ~~shall~~ are to have specially considered stern icebelt, S_i, and stern lower, S_l, hull area factors. *See* the *Provisional Rules for Classification of Stern First Ice Class Ships, November 2011.*

10.9 Shell plate requirements

10.9.1 The required minimum shell plate thickness, t, is given by:

$$t = t_{net} + t_s \quad \text{mm}$$

where

t_{net} = plate thickness required to resist ice loads according to *Pt 8, Ch 2, 10.9 Shell plate requirements 10.9.2*, in mm

t_s = corrosion and abrasion allowance according to *Pt 8, Ch 2, 10.16 Corrosion/abrasion additions and steel renewal*, in mm

10.9.2 The thickness of shell plating required to resist the design ice load, t_{net}, depends on the orientation of the framing. The plating~~, including all bottom plating, i.e. plating in hull areas B_{lb}, M_b and S_b, the~~ net thickness is given by *Table 2.10.~~5~~6 Shell plate thickness*.

Table 2.10.~~5~~6Shell plate thickness

Transversely framed plating *see* Note 1	Obliquely framed plating	Longitudinally framed plating	
Ω ≥ 70°	70° > Ω > 20°	Ω ≤ 20°	
		b ≥ *s*	*b* < *s*
$t_{net} = \dfrac{500s\sqrt{\dfrac{AF\,K_p\,P_a}{\sigma_y}}}{1+\dfrac{s}{2b}}$ mm	linear interpolation	$t_{net} = \dfrac{500s\sqrt{\dfrac{AF\,K_p\,P_a}{\sigma_y}}}{1+\dfrac{s}{2l}}$ mm	$t_{net} = \dfrac{500s\sqrt{\dfrac{AF\,K_p\,P_a}{\sigma_y}}\sqrt{\dfrac{2b}{s}-\left(\dfrac{b}{s}\right)^2}}{1+\dfrac{s}{2l}}$ mm

where

Symbols

Ω = smallest angle between the chord of the waterline and the line of the first level framing as illustrated in *Figure 2.10.3 Shell framing angle Ω*, in degrees

s = transverse frame spacing in transversely-framed ships or longitudinal frame spacing in longitudinally-framed ships, measured along the girth, in metres

AF = hull area factor from *Table 2.10.~~3~~4 Hull area factors (AF)* or *Table 2.10.5 Hull area factors (AF) for icebreakers*, as appropriate

K_p = peak pressure factor from *Table 2.10.~~2~~3 Peak pressure factors*

P_a = average patch pressure according to *Pt 8, Ch 2, 10.7 Pressure within the design load patch 10.7.1*, in MPa

σ_y = minimum upper yield stress of the material, in N/mm^2

b = height of design load patch, in m, where $b \leq l - \dfrac{s}{4}$ in the case of determination of the net thickness for transversely framed plating

l = distance between frame supports, i.e. equal to the frame span as given in *Pt 8, Ch 2, 10.10 Framing – General 10.10.5*, but not reduced for any fitted end brackets, in m. When a load-distributing stringer is fitted, the length, *l,* need not be taken larger than the distance from the stringer to the most distant frame support.

Note 1. Includes plating in hull areas B_{lb}, M_b and S_b regardless of actual frame orientation.

10.10 Framing – General

10.10.5 The ~~design~~ effective span of a framing member is to be determined on the basis of its moulded length. If brackets are fitted, the ~~design~~ effective span may be reduced in accordance with *Pt 3, Ch 3 Structural Design*.

10.10.7 The actual net effective shear area, A_w, of a transverse or longitudinal local frame ~~framing member~~ is given by:

$$A_w = \frac{h\,t_{wn}\sin(\varphi_w)}{100} \quad \text{cm}^3$$

where

h = height of stiffener, in mm, *see Figure 2.10.4 Stiffner geometry*

t_{wn} = net web thickness, in mm

= $t_w - t_c$

t_w = as built web thickness, in mm, *see Figure 2.10.4 Stiffner geometry*

t_c = corrosion deduction, in mm to be subtracted from the web and flange thickness (as specified by t_s in *Table 2.10.6 Shell plate thickness*, but not less than t_s as required by *Pt 8, Ch 2, 10.16 Corrosion/abrasion additions and steel renewal 10.16.3*)

φ_w = smallest angle between shell plate and stiffener web, measured at the midspan of the stiffener, *see Figure 2.10.4 Stiffner geometry*. The angle φ_w may be taken as 90° provided the smallest angle is not less than 75°.

10.10.8 When the cross-sectional area of the attached plate flange exceeds the cross-sectional area of the local frame, the actual net effective plastic section modulus, ~~Z~~ Z_p, of a transverse or longitudinal frame is given by:

$$Z_p = \frac{A_{pn} t_{pn}}{20} + \frac{h_w^2 \, t_{wn} \sin\varphi_w}{2000} + \frac{A_{fn}\left(h_{fc} \sin\varphi_w - b_w \cos\varphi_w\right)}{10} \quad \text{cm}^3$$

where

A_{pn} = net cross-sectional area of the local frame, in cm^2

t_{pn} = fitted net shell plate thickness, in mm (~~shall comply~~ complying with t_{net} as required by *Pt 8, Ch 2, 10.9 Shell plate requirements 10.9.2*)

h_w = height of local frame web, in mm, *see Figure 2.10.4 Stiffner geometry*

A_{fn} = net cross-sectional area of local frame flange, in cm^2

h_{fc} = height of local frame measured to centre of the flange area, in mm, *see Figure 2.10.4 Stiffner geometry*

b_w = distance from mid thickness plane of local frame web to the centre of the flange area, in mm, *see Figure 2.10.4 Stiffner geometry*

h, t_w, t_c and φ_w ~~are~~ as given in *Pt 8, Ch 2, 10.10 Framing – General 10.10.7*

s as given in *Pt 8, Ch 2, 10.9 Shell plate requirements 10.9.2*.

10.10.9 When the cross-sectional area of the local frame exceeds the cross-sectional area of the attached plate flange, the plastic neutral axis is located a distance z_{na} above the attached shell plate, given by:

$$z_{na} = \frac{100 A_{fn} + h_w \, t_{wn} - 1000 t_{pn} \, s}{2 t_{wn}} \quad \text{mm}$$

and the net effective plastic section modulus, Z_p, of a transverse or longitudinal frame is given by:

$$Z_p = t_{pn} \, s \, (z_{na} + \frac{t_{pn}}{2}) \sin\varphi_w + \left(\frac{\left((h_w - z_{na})^2 + z_{na}^2\right) t_{wn} \sin\varphi_w}{2000} + \frac{A_{fn}\left((h_{fc} - z_{na})\sin\varphi_w - b_w \cos\varphi_w\right)}{10} \right) \quad \text{cm}^3$$

10.11 Framing – Local frames in bottom structures and transverse local frames in side structures ~~Transversely-framed side structures and bottom structures~~

10.11.1 The local frames in bottom structures (i.e. hull areas B_{Ib}, M_b and S_b) and transversely-framed side structures ~~and in bottom structures (i.e. hull areas B_{Ib}, M_b and S_b)~~ are to be dimensioned such that the combined effects of shear and bending do not exceed the plastic strength of the member. The plastic strength is defined by the magnitude of midspan load that causes the development of a plastic collapse mechanism. For bottom structures the load patch shall be applied with the dimension *b* parallel to the frame direction.

10.11.2 The actual net effective shear area of the frame, A_w, as defined in *Pt 8, Ch 2, 10.10 Framing – General 10.10.7*, is to comply with the following condition:

$$A_w \geq A_t$$

where

A_t = $5000 \, l_L \, s \dfrac{AF \, K_t \, P_a}{0{,}577 \sigma_y}$ cm^2

l_L = length of loaded portion of span, in metres
need not exceed the lesser of *a* and *b*

a = local frame span as defined in *Pt 8, Ch 2, 10.10 Framing – General 10.10.5*, in metres

b = height of design ice load patch according to 10.6, in metres

s = ~~transverse~~ spacing of local frame ~~spacing~~, in metres

AF = hull area factor from ~~*Table 2.10.3*~~ *Table 2.10.4 Hull area factors (AF)* or *Table 2.10.5 Hull area factors (AF) for icebreakers*, as appropriate

K_t = peak pressure factor from *Table ~~2.10.2~~ 2.10.3 Peak pressure factors*, as appropriate

P_a = average pressure within load patch according to ~~2.~~*Pt 8, Ch 2, 10.7 Pressure within the design load patch,* in MPa

σ_y = minimum upper yield stress of the material, in N/mm^2

10.11.3 The actual net effective plastic section modulus of the plate/stiffener combination, Z_p, as defined in *Pt 8, Ch 2, 10.10 Framing – General 10.10.8* or *Pt 8, Ch 2, 10.10 Framing – General 10.10.9*, is to comply with the following conditions and is to be the greatest of the two load conditions:

(a) ice load acting at the midspan of the ~~transverse~~ local frame, and
(b) the ice load acting near a support.

$Z_p \geq Z_{pt}$

where

Z_{pt} = $\dfrac{100^3 l_L\, Y\, s\, AF\, K_t\, P_a\, a\, A_1}{4\sigma_y}$ cm^3

Y = $1-\dfrac{l_L}{2a}$

A_1 = reflects the two conditions and is to be taken as the greater of A_{1A} or A_{1B}

A_{1A} = $\dfrac{1}{1+\dfrac{j}{2}+k_w\dfrac{j}{2}\left(\sqrt{1-a_1^{\,2}}-1\right)}$

A_{1B} = $\dfrac{1-\dfrac{1}{2a_1 Y}}{0{,}275+1{,}44k_z^{\,0{,}7}}$

j = 1 for ~~framing~~ a local frame with one simple support outside the ice strengthened areas
= 2 for ~~framing~~ a local frame without any simple supports

a_1 = $\dfrac{A_t}{A_w}$

A_t = rule minimum shear area of ~~transverse~~ the local frame as given in *Pt 8, Ch 2, 10.11 Framing – Transversely-framed side structures and bottom structures 10.11.2*, in cm^2

A_w = effective net shear area of ~~transverse~~ the local frame (calculated according to *Pt 8, Ch 2, 10.10 Framing – General 10.10.7*), in cm^2

k_w = $\dfrac{1}{1+\dfrac{2A_{fn}}{A_w}}$

A_{fn} = as given in *Pt 8, Ch 2, 10.10 Framing – General 10.10.8*

k_z = $\dfrac{z_p}{Z_p}$ in general
= 0 when the frame is arranged with end bracket

z_p = sum of individual plastic section modulii of flange and shell plate as fitted, in cm^3
= $\dfrac{\dfrac{b_f t_{fn}^{\,2}}{4}+\dfrac{b_e t_{pn}^{\,2}}{4}}{1000}$

b_f = flange breadth, in mm, *see Figure 2.10.4 Stiffner geometry*

t_{fn} = net flange thickness, in mm
= $t_f - t_c$

t_c = as given in *Pt 8, Ch 2, 10.10 Framing – General 10.10.7*

t_f = as-built flange thickness, in mm, *see Figure 2.10.4 Stiffner geometry*

t_{pn} = the fitted net shell plate thickness, in mm, but is not to be less than t_n as given in *Pt 8, Ch 2, 10.9 Shell plate requirements*

b_e = effective width of shell plate flange, in mm
= 500s

Z_p = net effective plastic section modulus of ~~transverse~~ the local frame (calculated according to *Pt 8, Ch 2, 10.10 Framing – General 10.10.8* or *Pt 8, Ch 2, 10.10 Framing – General 10.10.9*), in cm^3

AF, K_t, P_a, l_L, b, s, a and σ_y are as given in *Pt 8, Ch 2, 10.11 Framing – Transversely-framed side structures and bottom structures 10.11.2*

10.11.4 The scantlings of the local frame are to meet the structural stability requirements of *Pt 8, Ch 2, 10.14 Framing – Structural stability*.

10.12 Framing – ~~Side longitudinals (longitudinally framed ships)~~ Longitudinal local frames in side structures

10.12.1 ~~Side longitudinals~~ Longitudinal local frames in sides structures are to be dimensioned such that the combined effects of shear and bending do not exceed the plastic strength of the member. The plastic strength is defined by the magnitude of midspan load that causes the development of a plastic collapse mechanism.

10.12.2 The actual net effective shear area of the frame, A_w, as defined in *Pt 8, Ch 2, 10.10 Framing – General 10.10.7*, is to comply with the following condition:

$A_w \geq A_L$,

where

A_L = $\dfrac{5000\,AF\,K_s\,P_a\,b_1\,a}{0{,}577\sigma_y}$ cm^2

AF = hull area factor from ~~*Table 2.10.3*~~ *Table 2.10.4 Hull area factors (AF)* or *Table 2.10.5 Hull area factors (AF) for icebreakers*, as appropriate

K_s = peak pressure factor from *Table ~~2.10.2~~ 2.10.3 Peak pressure factors*, as appropriate

P_a = average pressure within load patch according to *Pt 8, Ch 2, 10.7 Pressure within the design load patch 10.7.1*, in MPa

b_1 = $k_o\,b_2$ m

k_o = $1 - \dfrac{0{,}3}{b'}$

b' = $\dfrac{b}{s}$

b = height of design ice load patch from *Pt 8, Ch 2, 10.6 Design load patch*, in metres

s = spacing of longitudinal frames, in metres

b_2 = $b(1 - 0{,}25b')$ m if $b' < 2$

= s m if $b' \geq 2$

a = ~~longitudinal design span~~ effective span of longitudinal frame as given in *Pt 8, Ch 2, 10.10 Framing – General 10.10.5*, in metres

σ_y = minimum upper yield stress of the material, in N/mm^2

10.13 Framing – Web frame and load carrying stringers

10.13.2 Web frames and load-carrying stringers are to be dimensioned to take into account the combined effects of shear and bending. ~~Where these members form part of a structural grillage system, appropriate methods of analysis are to be used.~~ Where the structural configuration is such that members do not form part of a grillage system, the appropriate peak pressure factor, K_i, from *Table ~~2.10.2~~ 2.10.3 Peak pressure factors* is to be used. Special attention is to be paid to the shear capacity in way of lightening holes and cut-outs in way of intersecting members.

Existing paragraph 10.13.3 has been renumbered 10.13.4.

10.13.3 For determination of scantlings on load carrying stringers, web frames supporting local frames, or web frames supporting load carrying stringers forming part of a structural grillage system, appropriate methods as outlined in *Pt 8, Ch 2, 10.26 Direct calculations* are normally to be used.

10.13.4 The scantlings of web frames and load-carrying stringers are to meet the structural stability requirements of *Pt 8, Ch 2, 10.14 Framing – Structural stability*.

10.16 Corrosion/abrasion additions and steel renewal

10.16.1 Effective protection against corrosion and ice-induced abrasion is recommended for all external surfaces of the shell plating for ~~all~~ Polar Class ships.

10.16.2 The values of corrosion/abrasion additions, t_s, to be used in determining the shell plate thickness ~~for each Polar Class~~ are listed in *Table ~~2.10.6~~ 2.10.7 Corrosion/abrasion additions for shell plating*.

10.16.3 Polar Class ships are to have a minimum corrosion/abrasion addition of t_s = 1,0 mm applied to all internal structures within the ice strengthened hull areas, including plated members adjacent to the shell, as well as stiffener webs and flanges.

10.17 Materials

10.17.1 Steel grades of plating ~~Plating materials~~ for hull structures are to be not less than those given in *Table ~~2.10.8~~ 2.10.9 Steel grades for weather exposed plating* to *Table 2.10.11 Steel grades for inboard framing members attached to weather exposed plating* based on the as-built thickness ~~of the material~~, the Polar Class ~~ice class notation assigned to the ship~~ and the material class of structural members given in ~~*Pt 8, Ch 2, 10.17 Materials 10.17.2*~~ *Table 2.10.8 Material classes for structural members of polar ships*.

10.17.2 Material classes specified in *Table 2.2.1 Material classes and grades* in *Pt 3, Ch 2 Materials*~~,~~ are applicable to ~~polar~~ Polar Class ships regardless of the ship's length. In addition, material classes for weather and sea exposed structural members and for members attached to the weather and sea exposed plating are given in *Table 2.10.~~7~~8 Material classes for structural members of polar ships.* Where the material classes in *Table 2.10.~~7~~ 2.10.8 Material classes for structural members of polar ships* and those in *Table 2.2.1 Material classes and grades* in *Pt 3, Ch 2 Materials* differ, the higher material class is to be applied.

~~10.17.5 Steel grades for all inboard framing members attached to weather exposed plating are to be not less than given in Table 2.10.11. This applies to all inboard framing members as well as to other contiguous inboard members (e.g. bulkheads, decks) within 600 mm of the exposed plating.~~

~~**Table 2.10.11 Steel grades for inboard framing members attached to weather exposed plating**~~

~~**Thickness *t*,**~~ mm	~~**PC1 - PC5**~~		~~**PC6 & PC7**~~	
	MS	**HT**	**MS**	~~**HT**~~
$t \leq 20$	B	AH	B	AH
$20 < t \leq 35$	D	DH	B	AH
$35 < t \leq 45$	D	DH	D	DH
~~$45 < t \leq 50$~~	~~E~~	~~EH~~	~~D~~	~~DH~~

Existing Table 2.10.12 has been renumbered 2.10.11.

10.18 Longitudinal strength – Application

Existing paragraph 10.18.1 has been renumbered 10.18.3.

10.18.1 A ramming impact on the bow is the design scenario for the evaluation of the longitudinal strength of the hull.

10.18.2 Intentional ramming is not considered as a design scenario for ships which are designed with vertical side bow forms or bulbous bow forms, *see Pt 8, Ch 2, 1.4 Application for multi-year ice conditions 1.4.4*. Hence the longitudinal strength requirements given in *Pt 8, Ch 2, 10.22 Longitudinal strength criteria* are not to be considered for ships with stem angle γ_{stem} equal to or greater than 80°.

~~10.18.1~~ 10.18.3 Ice loads ~~need~~ are only to be combined with still water loads. The combined stresses are to be compared against permissible bending and shear stresses at different locations along the ship's length. In addition, sufficient local buckling strength is also to be verified.

Table ~~2.10.12~~ 2.10.11 Longitudinal strength criteria

Failure mode	Applied stress	Permissible stress	Permissible stress
		$\frac{\sigma_y}{\sigma_u} \leq 0,7$	$\frac{\sigma_y}{\sigma_u} > 0,7$
Tension	σ_a	$\eta\ \sigma_y$	$\eta\ 0,41\ (\sigma_u + \sigma_y)$
Shear	τ_a	$\frac{\eta\,\sigma_y}{\sqrt{3}}$	$\frac{\eta\,0,41(\sigma_u + \sigma_y)}{\sqrt{3}}$
Buckling	σ_a	σ_c for plating and for web plating of stiffeners $\frac{\sigma_c}{1,1}$ for stiffeners	
	τ_a	τ_c	

where

σ_a = applied vertical bending stress, in N/mm^2

τ_a = applied vertical shear stress, in N/mm^2

σ_y = minimum upper yield stress of the material, in N/mm^2

σ_u = ultimate tensile strength of material, in N/mm^2

σ_c = critical buckling stress in compression, according to *Pt 3, Ch 4 Longitudinal Strength*, in N/mm^2

τ_c = critical buckling stress in shear, according to *Pt 3, Ch 4 Longitudinal Strength*, in N/mm^2

η = 0,8

= 0,6 for ships which are assigned the additional notation **Icebreaker**

10.26 Direct calculations

10.26.1 Direct calculations are not to be utilised as an alternative to the analytical procedures prescribed for the shell plating and local frame requirements given in *Pt 8, Ch 2, 10.9 Shell plate requirements* to *Pt 8, Ch 2, 10.12 Longitudinal local frames in side structures*. ~~in this Section.~~

10.26.2 Direct calculations are to be used for load carrying stringers and web frames forming part of a grillage system.

~~10.26.2~~ 10.26.3 Where direct calculation is used to check the strength of structural systems, the load patch specified in *Pt 8, Ch 2, 10.2 Design ice loads –general* is to be applied~~.~~, without being combined with any other loads. The load patch is to be applied at locations where the capacity of these members under the combined effects of bending and shear is minimised. Special attention is to be paid to the shear capacity in way of lightening holes and cut-outs in way of intersecting members.

10.26.4 The strength evaluation of web frames and stringers may be performed based on linear or non-linear analysis. Recognised structural idealisation and calculation methods are to be applied, *see Pt 3, Ch 1, 2 Direct calculations*. In the strength evaluation, the guidance given in *Pt 8, Ch 2, 10.26 Direct calculations 10.26.5* and *Pt 8, Ch 2, 10.26 Direct calculations 10.26.6* may generally be considered.

10.26.5 If the structure is evaluated based on linear calculation methods, the following are to be considered:

(a) Web plates and flange elements in compression and shear to fulfil relevant buckling criteria in accordance with the applicable ShipRight SDA procedures. *See Pt 3, Ch 16, 3 Structural design assessment.*
(b) Nominal shear stresses in member web plates to be less than $s_y/\sqrt{3}$.
(c) Nominal von Mises stresses in member flanges to be less than 1,15 s_y.

10.26.6 If the structure is evaluated based on non-linear calculation methods, the following are to be considered:

(a) The analysis is to reliably capture buckling and plastic deformation of the structure.
(b) The acceptance criteria are to ensure a suitable margin against fracture and major buckling and yielding causing significant loss of stiffness.
(c) Permanent lateral and out-of plane deformation of considered member are to be minor relative to the relevant structural dimensions.

■ *Section 12*
Requirements for Icebreaker(+)

12.1 Scope

12.1.1 Where the notation **Icebreaker(+)** is assigned, the arrangement, powering and ~~dimensions~~ scantlings of the hull structure and propulsion machinery are to be determined based on the operational profile that corresponds to that which the icebreaker is envisaged to undertake as determined in the ship specific scenario document.

12.3 Information to be submitted

12.3.2 In addition to the information submitted in *Pt 8, Ch 2, 12.3 Information to be submitted 12.3.1*, a scenario document, which is ~~design~~ ship specific, is required to document the operational profile and is to include details of the scenarios selected for deriving and applying ice loads.

12.6 Hull strength

12.6.3 In addition to the ice pressure plan required in *Pt 8, Ch 2, 12.5 General arrangement 12.5.1*, consideration is to be given to the enhancement of longitudinal strength based on the operational profile. The utilisation factor, η, in *Table 2.10.12 Longitudinal strength criteria*, is to be adjusted accordingly.

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